

Frog Population Monitoring of Mulloon Creek

Report on December 2020 surveys

Report prepared for The Mulloon Institute



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1 INTRODUCTION

1.1 Summary overview of project

This report provides a summary of the amphibian population surveys undertaken at Mulloon Creek near Bungendore NSW in December 2020.

The Mulloon Institute (TMI) has been working with landholders at a catchment scale to rehydrate the landscape and improve functionality and land use management along a section of Mulloon Creek near Bungendore, NSW. In 2006, the Mulloon Institute, with backing from the Southern Rivers Catchment Management Authority, and through the Mulloon Creek Natural Farms (MCNF) business, began a Natural Sequence Farming rehydration pilot project at degraded sections of Mulloon Creek. The work has included the installation of numerous weirs within the creek to reinstate more natural 'pool and riffle' sequences.

The primary aim of this work was to slow the movement of water through the creek to recharge the groundwater system within the floodplain. The targeted benefits of slowing the movement of water and recharging the groundwater was to reduce erosion and improve the productivity of the landscape, including the overall biodiversity values of the aquatic and terrestrial systems in the area.

Based on the success to date of the project at a property scale, a multi-faceted scientific research program to collect hydrological, soil, and biological data to assess the impact of the catchment scale approach, is being undertaken.

Part of the biodiversity surveys has included assessing the existing amphibian populations in the area to determine how they might respond to or benefit from the rehydration project. An earlier frog survey was completed in 2017 by Frogwatch (Hoefler 2017). The recent surveys completed in December 2020 (and which are the focus of this report) were undertaken to establish (additional) baseline data on the existing frog community present within the defined study area of Mulloon Creek. This baseline data will facilitate comparative analysis of future frog monitoring surveys along the creek as part of a broader project to monitor the effectiveness the floodplain rehydration project.

The study area, survey methods including dates and timing of the surveys, as well as survey conditions, and results of the 2020 frog surveys are provided below.

1.2 Aims and objectives of this assessment

The broad aim of this project is to provide baseline data on the frog populations present within the defined sections of Mulloon Creek to allow for future comparisons of population numbers and assemblages to aid in the assessment of the benefits and effectiveness of the rehydration project. Baseline data is an important tool to measure key conditions (indicators) and is commonly gathered before a project begins, to be used to monitor and evaluate a project's progress.

The key factors included in the baseline data collection are broadly in relation to the following:

- Habitat features and values including certain water variables and vegetation characteristics
- Frog species (and general estimates of abundance) present within the defined sections of Mulloon Creek in the study area.

The Frog surveys along Mulloon Creek will assist in identifying areas of high(er) diversity in frog species composition at sites which may also indicate the availability of high quality habitat for various frog species. Identifying sites with higher quality habitat values will therefore assist in future decision-making, priority setting, planning and management of the area.

1.3 Study area - The Mulloon Creek

The study area is situated along Mulloon Creek which is situated in the Southern Tablelands of New South Wales between Braidwood and Bungendore (Figure 1). The specific location of this study includes a total of 19 monitoring transects.

The 19 transects are located between the MCNF Home Farm property in the southern/upstream parts of the Mulloon catchment. The Sandhills Creek catchment confluence in the northern/downstream parts of the catchment with Mulloon Creek and becomes Reedy Creek (Figure 2; note: Transect 28 is actually located on Reedy Creek, about 600m directly east of the confluence, and Mulloon Creek becomes/is named Sandhills Creek after this confluence). This study area represents a total distance of almost 20km of stream length between the upstream and downstream sites.



Figure 1. Location of study area on the Mulloon Creek, Southern Tablelands, NSW

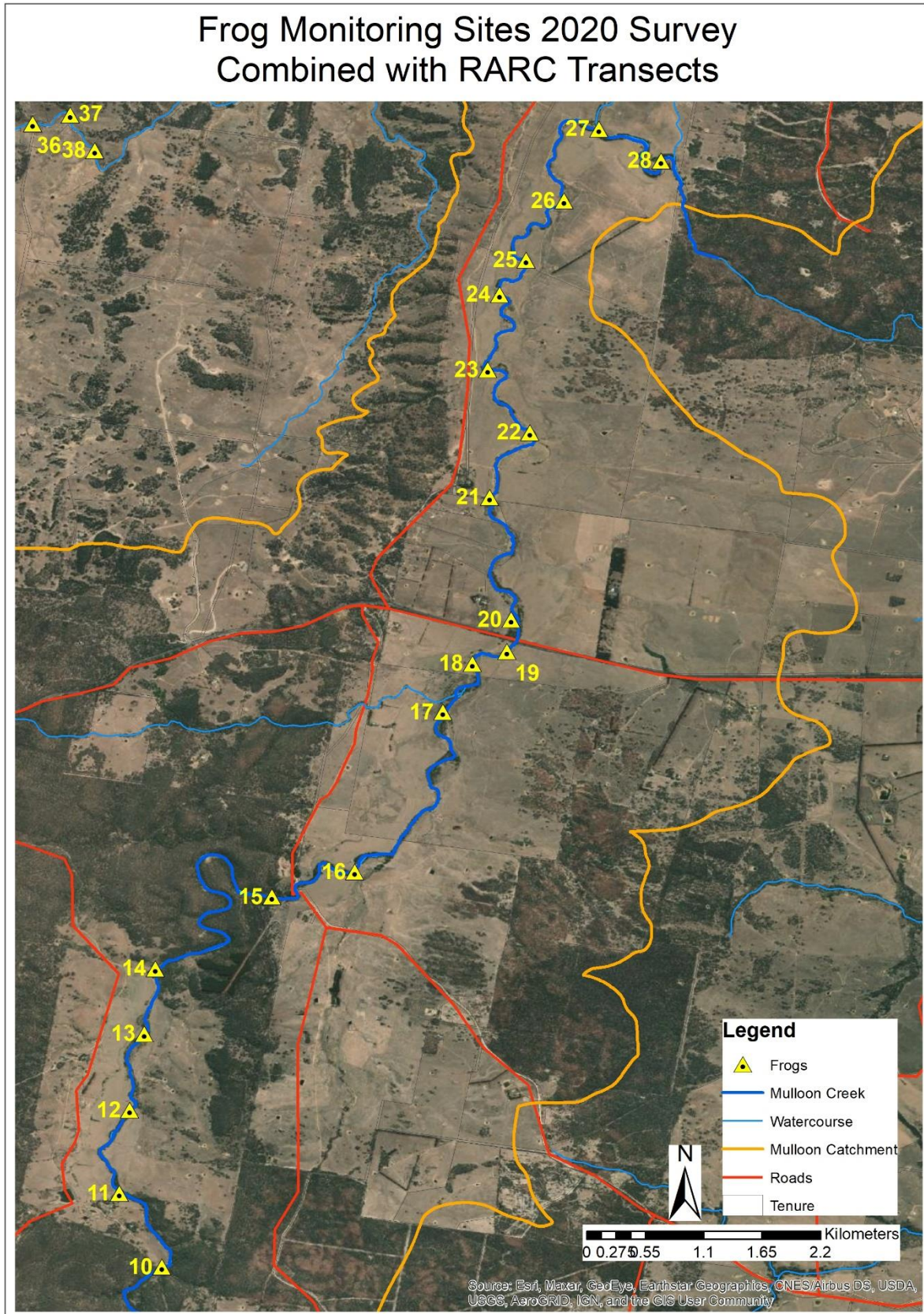


Figure 2. Study area – Mulloon Creek 2020 Frog Monitoring Transects

(image courtesy the Mulloon Institute: Bill McAlister, 2021)

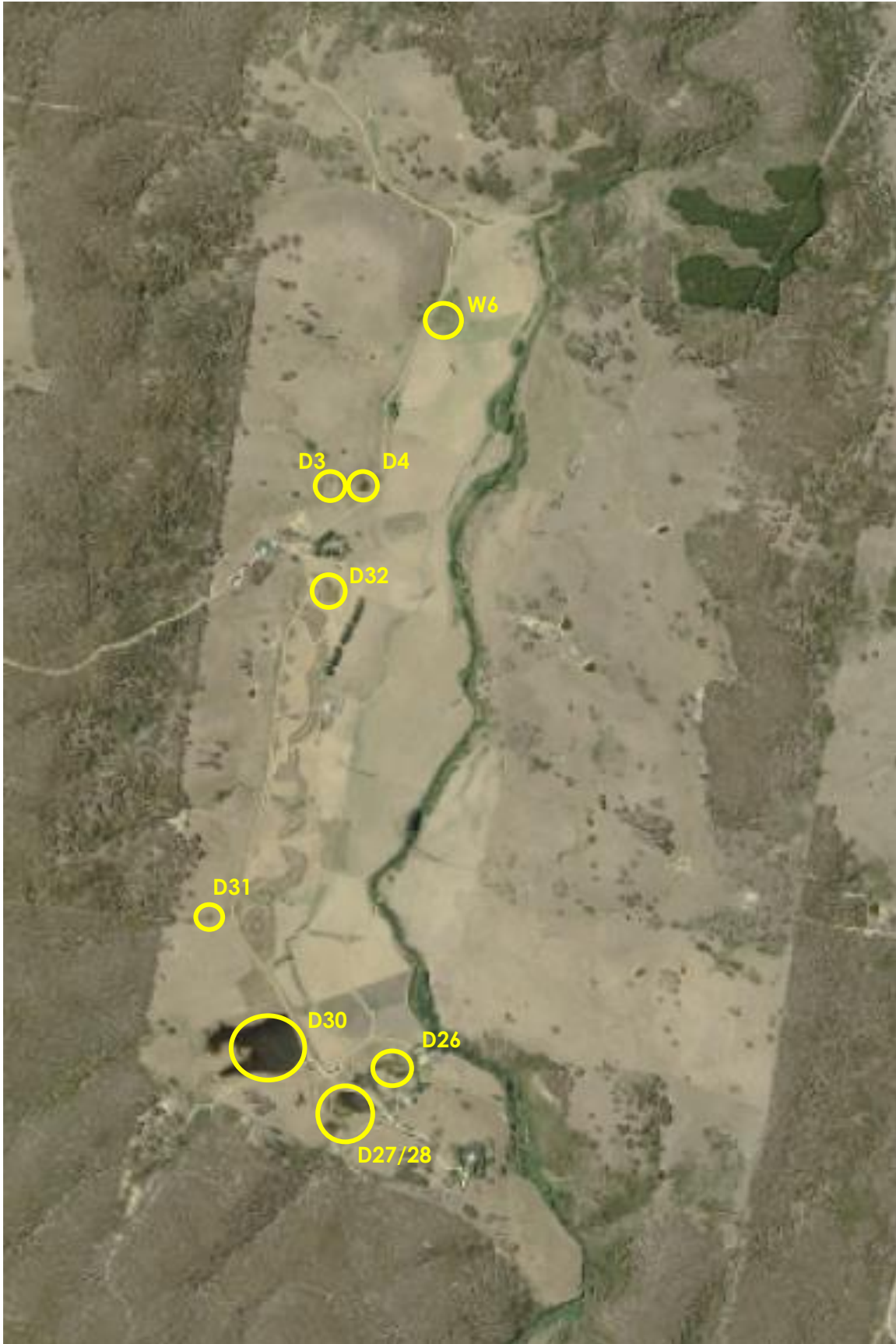


Figure 3. Location of (additional) farm dam/wetland monitoring sites at MCHF

2 Survey methods, effort, timing, and conditions

2.1 Survey methods and effort

A total of 38 survey sites were included in the December 2020 frogs surveys along Mulloon Creek. The 38 survey sites were pre-established by the Mulloon Institute and involved the 19 stream “transects” (originally established for the RARC monitoring project; see Figure 2), each of which are approximately (200m) length, with the survey sites located at each end of the transect (i.e. 200m apart). Each transect was spaced approximately 1km (in stream length) apart.

These 19 stream transects are located between the MCHF property in the south of the catchment (Transect 10) to the Sandhills property in the northern parts of the catchment at the confluence of Mulloon and Reedy Creeks (Transects 27 and 29. Note: Transect 28 is actually located on Reedy Creek, about 600m directly east of the confluence, and Mulloon Creek becomes/is named Sandhills Creek after this confluence). This represents a total distance of more than 19km of stream length between the upstream (Transect 10) and downstream (Transect 27/28) monitoring transects/sites.

At each survey site, a combination of habitat and weather variables were collected as well as records of frog observations. For the habitat and weather variables, during each survey the observer collected the air (and water where possible) temperature, noted the sky (i.e. cloud cover) and wind conditions. The water depth, pond level (as being on a scale between dry and full), water flow rate (on a scale of still to fast flowing), vertical water level drop (distance from top of bank to water level) and area of exposed soil (vertical distance from the High Water Mark (HWM) to the water’s edge) was also recorded. Observations of vegetation characteristics was also recorded at each site including the extent of emergent as well as fringe/edge vegetation, the extent of pond shaded by trees, evidence of mowing/slashing, as well as the width of the (unmown) buffer strip.

For the frog surveys, a timed 10-minute observation/recording period was undertaken at each site and included recording the frog species heard calling (where possible, based on observer skill level). Given the large number of sites and area covered by the survey and the requirement to complete the surveys in a short period of time (within a two-day/night period), it was necessary to bring in help to complete the work. For this survey, a number of TMI staff and volunteers were enlisted, some of whom had little experience in frog (call) species identification. For this reason, the use of (minimum 1-minute) audio file recording was employed. The call files were subsequently assessed, and the frog species recorded by an experienced herpetologist (Sam Patmore).

It is acknowledged that whilst not all frogs may have been captured during each audio recording, given the large total number of recordings made along the same stream and generally within close proximity and timing of each other (i.e. 100m apart for sites on the same transect and less than 1km (generally) for sites between transects), it is expected that a sound assessment of the overall amphibian community along Mulloon Creek was completed.

In addition to the 38 stream sites, additional frog surveys were undertaken at eight (8) of the 'farm dam' sites within MCHF (which includes a "wetland" site located in the lower floodplain valley floor – "Wetland 6"). The location of the additional farm dam sites is shown in Figure 3. Note, the dam/wetland sites did not include a habitat assessment as per the ACT Frogwatch data collection sheets used for the creek sites, given that these are not part of the creek (and are not flowing). A separate assessment will be developed for these sites to capture the appropriate habitat variables (note: existing habitat variables have been collected for these sites by PATH Co in 2019 as part of the habitat assessment of MCHF for the Green and Golden Bell Frog translocation project, PATH Co 2019). The main focus for this current survey was to collect baseline data on the frog populations present at these sites.

The procedures described above generally follow the ACT Frogwatch protocol and is therefore similar in manner to the 2017 survey (Hoefler 2017), allowing some comparison between the findings of the 2017 survey and the 2020 survey.

2.2 Survey timing and conditions

The surveys (both habitat and frog surveys) were completed on the 18th and 19th of December 2020. Generally, the habitat variables were collected during the daytime to facilitate observations of vegetation condition and stream flow features, although in some circumstances, due to timing constraints, some of the habitat assessments were conducted at night at the same time as the frog surveys. All of the frog surveys were completed at night, with surveys commencing no earlier than 20.30 hours once it was sufficiently dark and most frog species had become active/started calling.

The weather conditions for the surveys were generally suitable/ideal for frog surveys. The air temperatures on the 18/12/2020 were generally between about 17-19°C for most of the night but did drop to about 15°C after about 10pm (with some sites still being surveyed after this time). Temperatures on the 19/12/2020 were notably cooler at about 12°C. The sky conditions were generally recorded as being cloudy/overcast, with some light drizzle recorded on the evening of the 18/12/2020. Wind was generally recorded as being between a light breeze to a light wind.

Water temperature was measured at nine sites with temperatures ranging between 18 and 27 degrees Celsius (at an average of 21.5°C). This temperature range is not considered to be an accurate reflection of the temperature range normally expected along the same creek (which should be in the order of only a few degrees Celsius in range from lowest to highest temperature, and not close to a 9°C variation as measured by observers in this survey). This large range in temperature measurements is likely an artefact of the measurements coming from different observers using different measuring equipment (which had not been calibrated amongst the whole team prior to surveys commencing). As such, an accurate measure of water temperature was not made, although it can be stated with some confidence that the water temperature was not sufficiently cold (or hot) to have any likely significant bearing on the frog activity levels, and hence the frog population and composition assessed in this survey.

Table 1. Timing and conditions for the December 2020 Mulloon Ck frog surveys

Wetland Site No.	Survey Date	Survey Time	Air Temp (°C)	Water Temp (°C)	Sky	Wind
					(1 to 6)	(1 to 4)
Mulloon Creek (RARC) Sites						
10a	18/12/2020	11.30	18	nm	3	3
10b	18/12/2020	11.40	18	nm	3	3
11a	18/12/2020	11.55	19	nm	5	2
11b	18/12/2020	12.00	19	nm	5	2
12a	18/12/2020	12.25	19	nm	5	3
12b	18/12/2020	12.30	19	nm	5	2
13a	18/12/2020	13.00	19	21	3	2
13b	18/12/2020	12.45	19	nm	3	2
14a	18/12/2020	21.15	18	21.8	2-3	3
14b	18/12/2020	21.30	18	21.9	3	2
15a	18/12/2020	21.25	20	nm	3	3
15b	18/12/2020	21.31	20	nm	3	3
16a	18/12/2020	22.00	20	nm	3	3
16b	18/12/2020	21.53	20	nm	3	3
17a	18/12/2020	22.45	19	nm	3	3
17b	18/12/2020	22.50	19	nm	3	3
18a	19/12/2020	21.00	12	19.9	5	3
18b	19/12/2020	20.50	12	18.7	5	3
19a	19/12/2020	20.38	12	19.8	5	3
19b	19/12/2020	20.30	12.5	19.8	5	3
20a	18/12/2020	23.27	18	nm	4	3
20b	18/12/2020	23.35	18	nm	4	3
21a						
21b						
22a	18/12/2020	nr	18	nm	3	2
22b	18/12/2020	nr	18	nm	3	2
23a	18/12/2020	nr	18	nm	3	2
23b	18/12/2020	nr	18	nm	3	2
24a	18/12/2020	nr	18	nm	3	2
24b	18/12/2020	nr	18	nm	3	2
25a	18/12/2020	22.19	17	7.7	3	1
25b	18/12/2020	22.00	17	nm	3	1
26a	18/12/2020	nr	15	nm	3	1
26b	18/12/2020	23.55	15	24	3	1
27a	18/12/2020	23.21	15	nm	3	1
27b	18/12/2020	nr	16	nm	3	1
28a	20/12/2020	nr	17	27	n	r
28b	18/12/2020	nr	16	nm	3	1
Dam/Wetland Sites						
W6	18/12/2020	21.45	17	nm	3	3
D4	18/12/2020	22.00	17	nm	3	3
D3	18/12/2020	22.05	17	nm	3	3
D32	18/12/2020	22.15	17	nm	3	3
D31	18/12/2020	22.30	16	nm	3	3
D30	18/12/2020	22.40	16	nm	3	3
D27/28	18/12/2020	22.50	16	nm	5	3
D26	18/12/2020	23.10	16	nm	5	3

nr/nm = not recorded/not measured

3 RESULTS

3.1 Habitat Assessments

The results of the habitat assessments (36 completed) for the 38 monitoring sites are described below.

Water levels and stream banks

Generally, water depth estimates at most sites were >30cm (n=28 sites), with only four sites recorded at <30cm (and four sites recorded as 'unknown' but likely >30cm). Pond levels were recorded as being either 'nearly full' (n= 15) or 'bank very exposed' (n=21). Water flow rates was recorded at most sites as 'slow' (n=26) to occasionally 'moderate' (n=9), with a 'fast' flow rate recorded at one site (27a). No sites recorded a 'still' water flow rate.

The vertical water drop across site ranged from 0.25-10m with an average drop across sites of 2.4m. Ten sites had a vertical drop of 3m or more, and generally, (although not consistently or linearly), upstream sites had higher banks (measured by the vertical water level drop) than downstream sites.

These measurements indicate that although the creek was not full at the time of the survey, there was still good water flow through the system with all pools containing at least some water.

Vegetation

Emergent vegetation cover at ponds varied greatly across sites, although it was noted that all but one of the monitoring sites recorded emergent vegetation cover levels of less than 50%. Generally, most sites were recorded as having either 'just localised' (n=16) or <25% (n=12) emergent vegetation cover, with two sites recording no emergent vegetation cover, five sites recording 25-50% cover and one site (site 20a) recording a value of between 75-100% emergent vegetation cover.

Fringe or edge vegetation cover also varied greatly across sites, although all but one of the records were above 25% (with Site 26a a value of 10-25% edge vegetation cover). Most (n=28) records were above 75% edge vegetation cover (with n=15 sites having cover values of 50-75% and n=13 sites having cover values of 75-100%).

Levels of pond shading at sties ranged from <10% to <75% (n=10 sites had a shade level of 0-10%; n=7 sites had a shade level of 10-25%; n=11 sites had a shade level of 25-50%; and n=8 sites had a shade level of 50-75%). No sites recorded a shade level of 0% or 75-100%.

There was no recorded evidence of mowing or slashing within close proximity of the creek, with all but three of the sites (Sites 14b, 17a and 17b) recording no evidence of mowing within 5 m of the creek. A minimum 5m buffer was therefore recorded at 33 of the 36 sites.

The full results of the habitat descriptions and water quality measurements are provided at Appendix B and separately as a Microsoft Excel spread sheet.

3.2 Frog species detected during the December 2020 Surveys

The results of the frog surveys (36 completed) for the 38 monitoring sites are described below.

A total of 8 species were detected across the (36 completed) Mulloon Creek monitoring sites and (8) additional dam/wetland sites during the December 2020 surveys (Table 2).

This included the following species:

- *Crinia signifera*, Common Eastern Froglet
- *Crinia parinsignifera*, Plains Froglet
- *Limnodynastes peronii*, Striped Marshfrog
- *Limnodynastes dumerelli*, Eastern Banjofrog
- *Limnodynastes tasmaniensis*, Spotted Grassfrog
- *Litoria peronii*, Peron's Treefrog
- *Litoria verreauxii*, Whistling Treefrog
- *Uperoleia laevigata*, Smooth Toadlet

Table 2 below shows the number/frequency of sites that each species was detected at (and includes the 8 dam sites; therefore, the total number of sites each species was recorded at and the detection frequency is out of 44 completed frog survey sites).

Table 2. Species recorded and detection rates during the December 2020 Mulloon Ck frog surveys

Species Name	Common Name	Number of sites recorded at	Detection Frequency (% of sites detected at)
<i>Crinia parinsignifera</i>	Plains Froglet	21 (17/36 & 4/8)	48% (47% & 50%)
<i>Crinia signifera</i>	Common Eastern Froglet	30 (27/36 & 3/8)	68% (75% & 38%)
<i>Limnodynastes dumerilli</i>	Eastern Banjofrog	5 (5/36 & 0/8)	11% (14% & 0%)
<i>Limnodynastes peronii</i>	Striped Marshfrog	11 (10/36 & 1/8)	25% (28% & 13%)
<i>Limnodynastes tasmaniensis</i>	Spotted Grassfrog	12 (7/36 & 5/8)	27% (19% & 63%)
<i>Litoria peronii</i>	Peron's Treefrog	16 (11/36 & 5/8)	36% (31% & 63%)
<i>Litoria verreauxii</i>	Whistling Treefrog	14 (11/36 & 3/8)	32% (31% & 38%)
<i>Uperoleia laevigata</i>	Smooth Toadlet	3 (0/36 & 3/8)	8% (0% & 38%)

No species was detected at every single site in this survey. *Crinia signifera* was the most common species detected during the surveys, being detected at 30 of the 44 (or 68%) sites in total (including at 27/36, or 75%, of the creek sites).

Litoria verauxii, which was the most common species detected during the 2017 surveys and was detected at every single site during that survey, was recorded at only 11 of the 36 (or 31%) of the creek sites during the 2020 survey (and similarly, at only 3/8 or 38% of the dam/wetland sites, for a combined total of only 14/44 (32%) detection rate. The 2017 survey report noted that this species is recovering from population declines due to the amphibian chytrid fungus disease Chytridiomycosis (Ben Scheele, ANU pers. comms. to Hoefler, A.M.).

Limnodynastes peronii, which is a generally uncommon but often locally abundant species in the ACT region (Hoefler 2017), was not detected during the 2017 survey. This species was detected at 11/44 (25%) of the sites (and at 10/36 (28%) of the creek sites; it was detected at only one wetland site, W6) during the 2020 surveys. As noted by Hoefler, this species is very common in coastal regions of NSW and is typically positively associated with relatively high cover levels of emergent and riparian macrophytes and reeds. Its presence can often be seen as a relatively good indicator of good quality amphibian habitat.

Uperoleia laevis was the least frequently recorded species, being detected at only 3 (8%) sites in total, all of which were dam/wetland sites, and was not recorded within the creek during this survey. This species was recorded at 7 sites (11% detection rate) along the creek during the 2017 survey.

Limnodynastes dumerilii was the next least frequently recorded species, being detected at only 5 of the 36 (14%) creek sites and was not recorded at any of the dam/wetland sites. This contrasts markedly with the results of the 2017 survey where it was recorded at 26/63 (42%) sites during that survey.

The full results of the frog surveys are provided at Appendix A and separately as a Microsoft Excel spreadsheet.

3.2.1 Species richness at sites

The species richness per site describes the total number of species detected at a single site. The average number of species detected per site/survey across all sites (36 creek sites and 8 dam/wetland sites) was 2.55 (with an average of 2.44 species per creek site/survey and an average of 3 species per dam/wetland site/survey).

For the sites along Mulloon Creek, the greatest number of species found at any one site during the surveys was 5 species that were recorded at Site 26b (only).

A total of 6 sites recorded 4 species, 8 sites recorded 3 species, 14 sites recorded 2 species, and 7 sites recorded only 1 frog species.

For the dam/wetland sites, the greatest number of species found at any one site during the surveys was 4 species that were recorded at 5 of the (8) dam/wetland sites, with 1 site recording 2 frog species and 2 sites recording only 1 frog species.

There was no site (with the creek or dam/wetland sites) within the study area/survey that failed to record at least one frog species.

3.2.2 Species richness at transects (n=18)

The species richness at transects describes the total number of species detected at each transect (i.e. species counts combined for both sites Xa and Xb). For this assessment, the dam/wetland sites were discounted as these sites did not involve a transect with two survey sites (Xa and Xb).

For the transects along Mulloon Creek, an average of 3.56 species per transect were detected across the 18 transects completed in the survey. The greatest number of

species found at any one transect during the surveys remained at 5 species (as for the highest single site score), however this was recorded at 4 transects (compared with only 1 Site) in the survey. A total of 6 transects recorded 4 species, 5 transects recorded 3 species, 2 transects recorded 2 species, and only 1 transect (Transect 10) recorded a combined total of only 1 frog species (*C. signifera*). Half (9) of the transects completed had an increased combined number of species for the transect than for one (i.e. the highest) individual site species count.

4 DISCUSSION AND MANAGEMENT RECOMMENDATIONS

4.1 Discussion

The December 2020 frog surveys conducted at Mulloon Creek were undertaken at 38 creek sites (within the existing 19 RARC transects) and 8 (new) dam/wetland sites over a two-night period and during relatively ideal conditions. The habitat conditions for frogs were also quite good, with the region having experienced relatively good rainfall through late winter and spring 2020, and water levels and flow rates within the creek were quite good (for frog habitat conditions). Similarly, all of the dams/wetlands held water and were at least about 75% full or more. Given the rainfall and water levels, emergent aquatic and riparian fringe/edge vegetation levels were also quite good (for frog habitat conditions).

The surveys found a relatively healthy frog community along the creek and adjacent dams/wetlands (within MCHF only) with a total of 8 species recorded during the survey. The 2017 survey recorded 7 species of frogs, with the additional species recorded being *Limnodynastes peronii*.

Despite recording an extra species, the overall species detection rate (being the number of species recorded at a single survey site) was lower during the current 2020 survey than that for the 2017 survey, with an average of 2.55 species recorded per site across all sites, and only 2.44 species per creek site/survey (with an average of 3 species per dam/wetland site/survey). This compares against 3.68 species per site/survey during the 2017 survey. Additionally, for species richness per transect, the current 2020 survey recorded an average of 3.56 species per transect compared to an average of 5 species per transect recorded during the 2017 survey. Further, for the sites along Mulloon Creek, the greatest number of species found at any one site during the 2020 survey was 5 species, and recorded at only one site, whereas during the 2017 survey, the greatest number of species at a single site/survey was 6 species and this number was recorded at 8 (of 63) survey sites.

Possible reasons for the overall lower detection rate and species richness recorded during the 2020 survey may include either or a combination of overall survey effort and/or observer skill. Specifically, for some sites, the audio recording was less than 2 minutes in length, and the observer was not confident in their call identification skills. Therefore, despite the audio recordings being reviewed by a specialist, it is possible that given this short recording period (as well as at times, low quality recordings), some frog calls may have been missed/not recorded at a site despite the frog possibly being present within (or nearby) to the site.

It is noted also that the 2017 surveys were conducted in October following previous good rainfall, whereas the 2020 surveys were conducted in December, and although there was also good rainfall leading up to the surveys, there had been two previous years of very dry/drought conditions which may have reduced overall

abundances of various frog species in the area. Despite the good rainfall leading up to the 2020 surveys, there would not have been sufficient time for population numbers (and distribution across the study area) have built up again to result in high levels of species richness and detection frequency across the study area. It is hoped that the good conditions observed in 2020 will be reflected in increased frog species richness and detection frequency in 2021 surveys (if conducted).

Importantly, there was no (significant) difference between the 2017 and 2020 surveys in the overall number of species recorded in the survey as stated above (n=7 vs 8 species respectively). Notably however, one species, *Uperoleia laevis* was not recorded at the creek during the 2020 survey, being recorded at (n=3/8) wetland/dam sites only, although it was recorded during the 2017 survey. Consequently, the total number of species recorded within Mulloon Creek during both the 2017 and 2020 surveys was 7 species, with the notable differences of *Limnodynastes peronii* found during the 2020 survey and not during the 2017 and *Uperoleia laevis* as described above.

From these surveys, it is not considered possible or reasonable to attempt to identify any broader patterns in population abundance, and whether or not there is any detectable trend in the overall abundance of the frog populations present in the study area (by total number of frogs or numbers for each species of frog). Consequently, a conclusion cannot (and should not) be drawn that there is any decrease in the frog community abundance based on the comparative results between the 2017 and 2020 surveys presented here. However, the results show that there is a moderately diverse and well-distributed frog community within the Mulloon Creek study area, with habitat conditions for frogs considered to be quite good, and as stated in the results, no site failed to detect at least one frog species.

Some possible management recommendations to ensure the ongoing health and future potential increase in the frog community are listed below.

4.2 Management Recommendations

Some early/preliminary management recommendations related to ensuring the maintenance of a viable (sustainable and diverse) frog community at Mulloon Creek, and primarily only for consideration and early discussion, include the following:

1. Continue to maintain in good repair all existing fencing along the creek to exclude/control livestock access.
2. Consider constructing additional fencing along sections of the creek that are currently unfenced.
3. Reduce/manage degradation of in-stream and riparian habitat through addressing any active sediment and erosion inputs.

Some thought has been given as to whether a strategy for the longer-term management/removal of Blackberry along creek banks should be recommended for implementation. Blackberry could potentially provide a limiting factor or barrier to frog movements along the creek given the density/thickness of (some) patches where it has

taken hold combined with its thorny nature which could damage the soft skin of a frog. However, it is understood that Blackberry, as well as other weed/non-native species, may play an important role in maintaining bank stability, and its removal could threaten/undermine this stability leading to unwanted impacts associated with bank slump, erosion and sedimentation of the creek.

Consequently, further thought would be needed as to how to best manage this issue and the overall benefits weighed, including assessing whether the risks of negative impacts associated with the work would outweigh any positive impacts. For consideration, it is noted that (most) frogs could likely still move quite freely up and down the creek from within the water itself, and so the presence of the Blackberry is unlikely to create a complete barrier to movements. Additionally, the Blackberry may also provide some shelter/cover for adult frogs from (larger) predators (for example birds/foxes).

Perhaps the key issue is ensuring that further spread and establishment of dense thickets of Blackberry are managed to an acceptable degree. It is also noted that this recommended removal would not (necessarily) apply to other non-native species (specifically in relation to improving/maintaining frog movement opportunities).

In relation to other pest/weed species, it was noted that there appears to be little evidence of (high levels of) predatory fish such *Gambusia*. No specific recommendation for control of this pest species is considered necessary (at this point in time). It is recommended that continued monitoring of pest/predatory fish species be conducted so that actions may be considered if required.

Some recommendations for consideration for future possible longer-term habitat creation, enhancement, or expansion include:

- Construction/establishment of further artificial wetlands within MCHF (as discussed and recommended in the *Habitat Assessment & Translocation Strategy for the Green and Golden Bell Frog* report prepared by PATH Co (2019). For example, site W16 in that assessment was identified as a potentially suitable site for undertaking wetland creation/enhancement works including establishing a method for the artificial filling/drainage of the wetland as well as some revegetation works.
- Consider further riparian revegetation along sections of the creek where natural/native riparian vegetation species are limited.

Recommendations for further/ongoing research and monitoring to assist with managing the site for the benefit and maintenance of frog communities include the following:

- Continue this current monitoring program on a (minimum) 2 year frequency (however, yearly assessments may be preferable; depending on the level of rehydration works being undertaken). If this current monitoring program is to be continued, it is recommended that there be a (minor) increase in survey effort, particularly in relation to the following:
 - Increase the recording time at each site (to minimum 5 minutes) to increase chances of detecting frogs calling at a site.

- Consider adding some additional parameters such as more water chemistry variables (e.g. pH, Conductivity etc). Note that water chemistry variables along a continuous aquatic system like Mulloon Creek may only need to be assessed as a smaller sub-set of sites/transects.
- Consider also increasing information on vegetation parameters, including noting dominant species of emergent aquatic and fringe/edge vegetation. Tracking any changes in the vegetation composition and structure over time would be useful for comparisons with any potential changes in frog species richness (and abundance) over time that could be attributable to these vegetation changes.
- Undertake additional surveys of other habitats (i.e. additional dams/wetlands) as well as additional sections (i.e. upstream/downstream) along Mulloon Creek, particularly if it is anticipated that further landholders will become involved so as to establish baseline data for these areas.

5 REFERENCES

Hoefler, A.M. (2017). *Project report Findings of frog surveys along Mulloon Creek Spring 2017*. Unpublished report prepared by ACT and Region Frogwatch: Ginninderra Catchment Group for the Mulloon Institute.

PATH Co Pty Ltd (2019). *Habitat Assessment & Translocation Strategy for the Green and Golden Bell Frog Mulloon Creek Home Farm*. Unpublished report prepared for the Mulloon Institute.

Appendix A. Frog Survey Records

The table below provides the species recorded as present (i.e. heard calling) at each site as well as the estimated number of individuals of each species present at the site. The estimated number of individuals present at a site has been grouped into size class categories¹ as follows:

- (a) = single frog only
- (b) = 2-5 frogs
- (c) = 6-10 frogs
- (d) = more than 10 frogs

Table A1. Full list of frog species recorded at (19) RARC transects (n=36 sites) along Mulloon Creek during the December 2020 Frog Surveys

Species	10a	10b	11a	11b	12a	12b	13a	13b	14a	14b	15a	15b	16a	16b	17a	17b	18a	18b	19a	19b	20a	20b	21a	21b	22a	22b	23a	23b	24a	24b	25a	25b	26a	26b	27a	27b	28a	28b	TOTAL SITES
<i>C. par.</i>									b		?	b			b	b	a*	b	b	b	b		c	c		c					c	c			b	a	b		17
<i>C. sig.</i>	c	b	b			b	b	b			c	c	c	b	b	b	b	b	c	c		b	b	b	c		b	b	b	b		b	b	b			b	a	27
<i>Lim. dum.</i>							a	a	b																								a		a			5	
<i>Lim. per.</i>				b	c										c		a	b	a		d	b						b						b				10	
<i>Lim. tas.</i>					b					b			b	?	b																b			b	a	?		7	
<i>Lit. per.</i>						b		b	b	c	c	b	b	b	?		a*		a														a	?				11	
<i>Lit. ver.</i>			b		a		a		a	b		b						a*											a		b			b				11	
<i>U. lae.</i>																																					0		
TOTAL SPECIES	1	1	2	1	3	2	3	3	3	4	2	3	4	2	4	2	4	4	4	2	2	2	3	2	2	1	1	2	2	1	3	2	1	5	3	2	2	1	7

*: outside of site (i.e. upstream/downstream or outside of creek corridor/riparian zone)

Table A2. Full list of frog species recorded at the (n=8) dam and wetland sites at MCHF during the December 2020 Frog Surveys

Species	W6	D4	D3	D32	D31	D30	D27/28	D26	TOTAL SITES
<i>C. par.</i>		c		c			b	c	4
<i>C. sig.</i>	b	b		b					3
<i>Lim. dum.</i>									
<i>Lim. per.</i>	c								1
<i>Lim. tas.</i>	b		b			b*	b	c	5
<i>Lit. per.</i>		b		b	b		b	b	5
<i>Lit. ver.</i>	a			a				b	3
<i>U. lae.</i>		b			b		b	?	3
TOTAL SPECIES	4	4	1	4	2	1	4	4	7

*: outside of site (i.e. not within dam or immediate riparian zone)

Species Code:

C. par. = *Crinia parinsignifera*

C. sig. = *Crinia signifera*

Lim. dum. = *Limnodynastes dumerilii*

Lim. per. = *Limnodynastes peronii*

Lim. tas. = *Limnodynastes tasmaniensis*

Lit. per. = *Litoria peronii*

Lit. ver. = *Litoria verreauxii*

U. lae. = *Uperoleia laevigata*

¹ Note: these categories are not the same as those used in the frogwatch data sheet given the generally low numbers of frogs heard, and so the categories were re-established to form smaller size classes for the (estimated) number of frogs present (heard calling). In the frogwatch datasheet, the second lowest category was 6-20 frogs which would have been achieved at very few sites, and no sites would have had frog numbers in the third group/category or higher (i.e. more than 20 frogs present).

Appendix B. Habitat Survey Data

Table B1. Habitat Survey Details at (19) RARC transects (n=36 sites) along Mulloon Creek during the December 2020 Frog Surveys

Site Ref No	Sky	Wind	Air Temp	Water Temp	Water Depth	Pond Level	Water Flow	Vertical Water Level Drop (m)	Area Exposed Soil (m)		Emergent Aquatic Veg Cover	Fringe/Edge Veg Cover	Pond Shading	Mowing? (Y/N)	Width of buffer
									Min	Max					
10a	3	3	18	nm	3	2	2	10	0	10	2	6	5	N	3
10b	3	3	18	nm	2	2	3	10	0.5	2	2	6	4	N	3
11a	5	2	19	nm	3	2	2	8	0	0.5	2	6	5	N	3
11b	5	2	19	nm	2	2	2	6	0	0.5	1	6	4	N	3
12a	5	3	19	nm	2	2	2	1	0	1	2	7	5	N	3
12b	5	2	19	nm	2	2	2	2.5	0	1.5	3	7	3	N	3
13a	3	2	19	21	2	2	2	0.5	0	0.5	3	7	2	N	3
13b	3	2	19	nm	3	2	2	0.5	0	0.5	1	7	4	N	3
14a	2-3	3	18	21.8	2	2	3	0.4	0	0.3	3	6	5	N	3
14b	3	2	18	21.9	3	2	2	0.5	0	0.5	3	6	3	y	2
15a	3	3	20	nm	2	3	2	3	0	0.5	2	7	5	N	3
15b	3	3	20	nm	2	3	2	3	0	1	2	6	4	N	3
16a	3	3	20	nm	2	3	3	2	0.5	1	2	5	4	N	3
16b	3	3	20	nm	2	3	2	3	0	1	3	6	2	N	3
17a	3	3	19	nm	2	3	2	2.5	0	0	4	7	4	N	1
17b	3	3	19	nm	1	3	2	1.5	0	0.25	4	7	3	N	1
18a	5	3	12	19.9	2	2	2	0.25	0	0.5	4	5	2	N	3
18b	5	3	12	18.7	2	2	2	0.25	0	0.5	4	5	4	N	3
19a	5	3	12	19.8	2	2	2	1	0	1	3	6	4	N	3
19b	5	3	12.5	19.8	2	2	2	0.5	0	0.5	3	5	2	N	3
20a	4	3	18	nm	1	3	2	2	0	0	6	7	2	N	3
20b	4	3	18	nm	1	3	3	4	0	0.5	3	7	2	N	3
22a	3	2	18	nm	2	3	2	3	0	0.5	4	6	2	N	3
22b	3	2	18	nm	2	3	2	3	0	2	3	6	2	N	3
23a	3	2	18	nm	2	3	2	2	0.5	2	2	5	5	N	3
23b	3	2	18	nm	2	3	3	2.5	0	0.5	3	6	5	N	3
24a	3	2	18	nm	2	3	3	1.5	0	0.5	2	7	4	N	3
24b	3	2	18	nm	2	3	2	1.8	0	0.2	2	6	4	N	3
25a	3	1	17	7.7	2	3	2	2	0	2	3	5	3	N	3
25b	3	1	17	nm	2	3	2	2	0	0.25	2	7	3	N	3
26a	3	1	15	nm	2	3	2	1.5	1	3	2	4	2	N	3
26b	3	1	15	24	2	3	2	2	0	0.5	2	6	3	N	3
27a	3	1	15	nm	1	3	4	0.5	1	2	2	6	3	N	3
27b	3	1	16	nm	2	3	3	2.5	0	0.5	2	7	4	N	3
28a	n	r	17	27	2	3	3	0.25	1	2	2	5	2	N	3
28b	3	1	16	nm	2	2	3	0.25	0	1	3	1	5	N	3

Table B2. Description of score categories for habitat variables in Table B.1

Sky (1 to 6)	Wind (1 to 4)	Water Depth (1 to 4)	Pond Level	Water Flow (1 to 4)	Emergent Aquatic Veg Cover	Fringe/Edge Veg Cover	Pond Shading	Width of buffer
1 = clear/few clouds	1 = Still	1 = <30	1 = Full	1 = Still	1 = none	1 = none	1 = none	1 = <1m
2 = Partly cloudy/variable	2 = Light Breeze	2 = >30	2 = Nearly Full	2 = Slow	2 = just localised	2 = just localised	2 = <10%	2 = 1-5m
3 = Cloudy/overcast	3 = Light Wind	3 = unknown	3 = Bank V. Exposed	3 = Moderate	3 = <25%	3 = <10% edge	3 = <25%	3 = >5m
4 = Fog	4 = Windy	4 = Dry	4 = Nearly Dry	4 = Fast	4 = <50%	4 = <25% edge	4 = <50%	
5 = Drizzle			5 = Dry		5 = <75%	5 = <50% edge	5 = <75%	
6 = Showers					6 = <100%	6 = <75% edge	6 = <100%	
					7 = entire pond	7 = <100% edge		
						8 = entire edge		