Fish Passage Surveys

-Williams Road Culvert-

Olleycology Limited

29th June 2022 (Revised 31st June 2023)

Contents

Scope

Undertake fish monitoring to assess the impact the fish passage remediations have made at the Williams Road culvert.

Introduction

Fish passage monitoring was undertaken at a culvert crossing of Williams Creek. Williams Creek is a small tributary of Tasman Valley Stream which flows into the Moutere Inlet in Tasman Bay (Figure 1). Approximately 20m upstream of its confluence with Tasman Valley Stream, Williams Creek is piped through two identical concrete culverts where it crosses Aporo Road (Figure 2). This crossing is located approximately one kilometer inland from the Moutere Inlet and it the first barrier fish would encounter while moving up from the coast. Both culverts are 1.2 m diameter, 18 m long and have gradients varying between 1-2% (Table 1). Both culverts are also perched by 0.3 m and undercut 0.05 m (Table 1). Maximum water velocities through the pipes were similar with 0.6m/s recorded through the true left pipe and 0.50m/s through the true right pipe under normal flow conditions (Table 1).

It was considered likely that the drops at the culvert outlets were impeding successful upstream passage of at least some fish species. While relatively low in gradient, the laminar flow and water velocities within the culverts may have also been acting as a barrier to fish.

Based on the likelihood of this structure being a barrier to fish, and the similar structural characteristics of the culvert pipes allowing for an “impact” and “control” type set up, the site was chosen for post remediation monitoring. Passive trapping and eDNA sampling were used to assess the impact the fish passage remediation work had made.

Remediation at the site, which was completed on the 19th of November 2021, aimed to improve upstream passage for all fish species on one of the pipes, without compromising culvert capacity and causing blockages. It was also hoped that some degree of in-pipe habitat would be provided for fish in the form of pools and bed material.

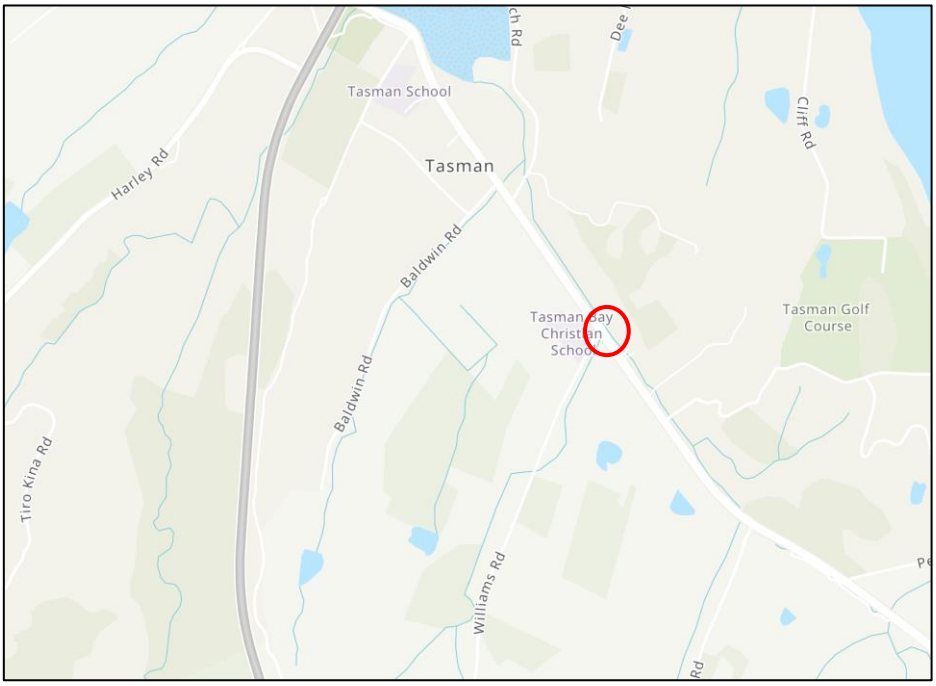


Figure 1. Site location for the Williams Road Culvert (red circle).

Table 1. Culvert characteristics at William's Creek.

	True right-hand pipe	True left-hand pipe
Culvert length (m)	18	18
Culvert diameter (m)	1.2	1.2
Culvert gradients (m)	0-2%	0-2%
Culvert material	Concrete	Concrete
Culvert perch height (m)	0.3	0.3
Culvert undercut length (m)	0.07	0.08
Max water velocity (m/s)	0.5	0.6
Flow rate (l/s)	4.5	4.2

Figure 2. Perched culverts at William's Creek prior to remediation.

Methods

To assess the effectiveness of the remediation, an A-frame net was setup at the inlet of each of the culvert pipes to capture fish as they moved through each of the structures (Figures 3 & 4). This allowed for an impact (remediated pipe) and control (unremediated pipe) experiment setup. Fine mesh was used to ensure no gaps were present and the A-frame nets had "non return" zones (Figure 5). The nets were checked daily (in the morning) to collect, record and release fish. Fish were released upstream of the structure. Species and fish lengths were recorded along with conductivity and water temperature.

Prior to the trial commencement both culverts were searched for fish, then two days of monitoring took place to assess whether fish were moving through either pipe after which the true left-hand culvert pipe was remediated.

Post remediation, the nets were left in-situ for twenty-one days from the 20th of November to the 10th of December 2021.

At the conclusion of the trial the culverts were searched again to recover and record any fish that remained within the pipe.

A passive eDNA sampler was placed upstream of the Williams Road culvert prior to the fish passage remediation (3 replicates) followed by two further surveys 12 months (6 replicates) and 18 months after remediation (6 replicates).

Figure 3. Culvert inlets at William's Creek.

Figure 4. A-frame nets set upstream of both culverts.

Figure 5. View from inside the true left-hand culvert looking upstream into the A-frame net.

Fish passage remediation

With reference to the Fish Passage Remediation Training Aid 2022, a total of seven flexible baffles were secured within the true left culvert pipe to reduce water velocities and create resting pools (Figure 6). All seven baffles were 450 mm wide and 100 mm high with slits at 50 mm spacing. 45-degree cuts at both ends to allow fish passage around the baffle. The spacing between baffles, and the number of baffles installed, was determined by the culvert gradient. Where gradients were between 0-1%, baffles were spaced at 2.4m intervals. Where gradients were between 1-2%, baffles were spaced at 1.2m intervals.

Figure 6. Flexible baffles within the true left-hand culvert pipe.

The most downstream baffle had a “V” cut midway through to enable rope to pass through the baffles and for it to be secured immediately upstream (Figure 7). This allows fish an opportunity to transition into the pipe either using climbing or swimming modes. The baffles were attached to the concrete culvert floor with stainless-steel wedge anchors (M6 x 50 mm) and stainless-steel penny washers (32 mm).

Figure 7. V-baffle and mussel-rope at the culvert outlet.

A flexible fish ramp, made of reinforced PVC rubber, was installed at the outlet of the true left culvert to negate the perch (Figure 8). The ramp was 900mm wide by 1500mm long and laid at a gradient of 40 degrees. The ramp was installed to the culvert floor with the same fixings as the baffles and included a bundle of looped mussel-rope fixed to the ramp invert consisting of four strands of rope. Flexible ramps with mussel-rope are designed to offer aquatic species several choices when migrating e.g., passage over/through mussel-rope, adjacent to mussel-rope or on the wetted margins at the edges of the ramp.

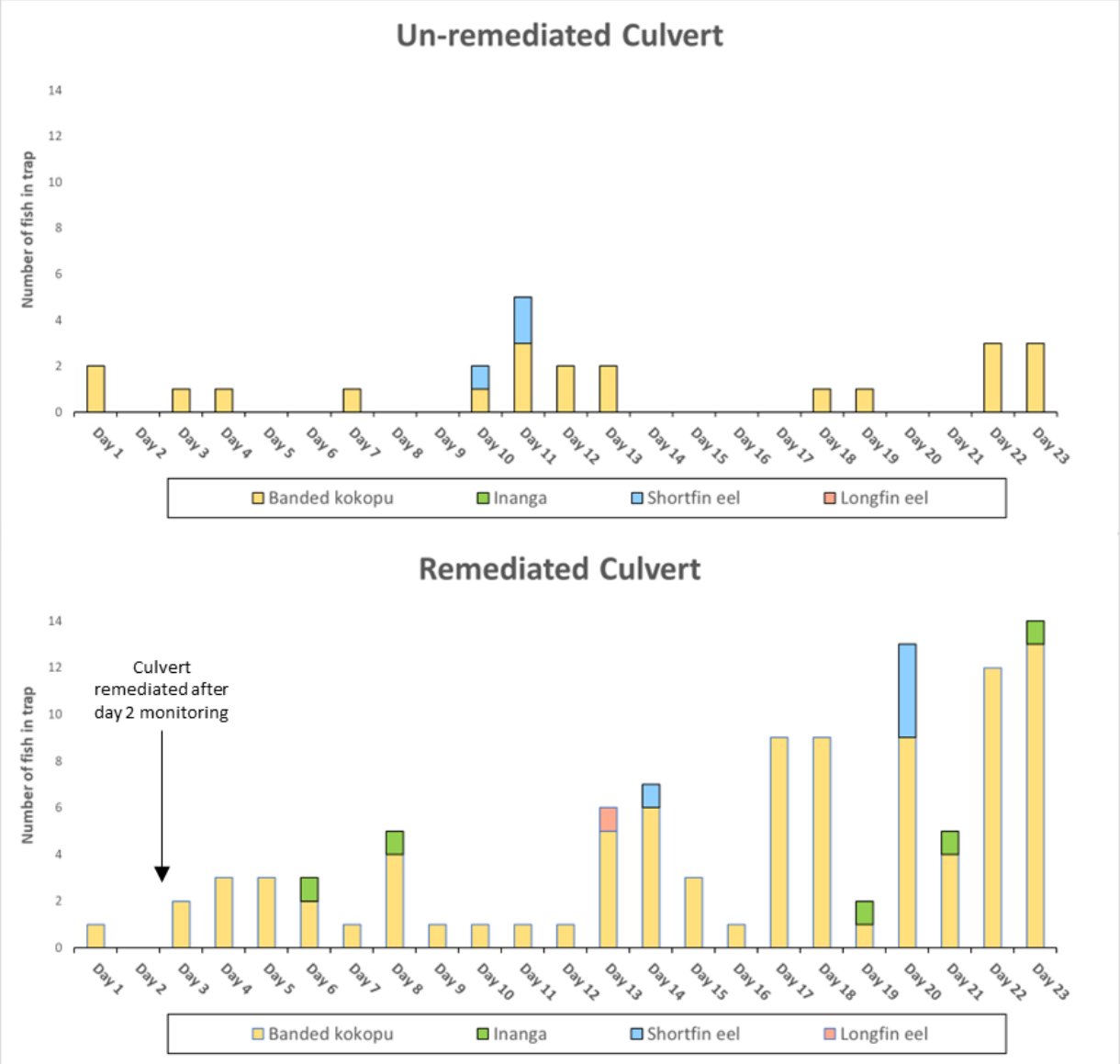
Figure 8. Flexible rubber ramp with mussel-rope

Monitoring results

At the commencement of the experiment both culverts were searched to capture and record any fish that were present within the culverts. No fish were found.

In the two days prior to any remediation juvenile banded kokopu (*Galaxias fasciatus*) were the only fish recorded passing through the culverts, with one fish caught in the true left-hand culvert net and two fish caught in the true right-hand culvert net during this time.

Following fish passage remediation, a total of 102 fish negotiated the remediated culvert over 21 days, compared with 22 fish that negotiated the unremediated culvert (Graph 1).



Graph 1. Numbers of fish caught in the A-frame nets of both the unremediated and remediated culverts.

Banded kokopu made up most of the fish that were caught throughout the experiment, with nearly five times as many moving through the remediated culvert compared to the unremediated culvert. The size range for these fish were 33-80mm in length from the remediated culvert compared to 35-45mm in length from the unremediated pipe.

A small number of shortfin eels (*Anguilla australis*) were also able to negotiate both culverts with five individuals captured in the remediated culvert net and three in the unremediated culvert net over the monitoring period (Graph 1).

Two species of fish, inanga (*Galaxias maculatus*) and longfin eel (*Anguilla dieffenbachii)* were found only in the remediated culvert net. One longfin eel was captured in the remediated culvert net on day 13 while five inanga were captured in the remediated culvert net during the monitoring period (Graph 1). The size range for these inanga were 51-65mm in length.

At the conclusion of the monitoring, both culverts were searched to capture and record fish that were still within the culvert pipes. 58 fish were recovered from the remediated culvert pipe and one fish, a banded kokopu measuring 37mm in length, was recovered from the unremediated culvert pipe. Of the 58 fish captured from within the remediated culvert, two were shortfin eels, 20 were banded kokopu and 36 were inanga (Table 2 & Figure 9). The banded kokopu size ranged from 38-100mm in length, and the inanga 47-76mm in length (Table 2). The vast majority of these fish were captured within the top third of the culvert pipe.

Results from the eDNA sampling showed three species of fish present upstream of the structure prior to the remediation and subsequent experiment - banded kokopu, longfin eel, and shortfin eel. 12 months later, eDNA identified four species of fish upstream – banded kokopu, longfin eel, shortfin eel and redfin bully (*Gobiomorphus huttoni*). 18 months later, eDNA identified six species of fish upstream – banded kokopu, longfin eel, shortfin eel, redfin bully, inanga and giant kokopu (*Galaxias argenteus*).

Table 2. Species and number of fish captured within the culverts at the conclusion of the monitoring period.

	Remediated culvert				Un-remediated culvert			
End of trial culvert search	Banded kokopu	Inanga	Shortfin eel	Longfin eel	Banded kokopu	Inanga	Shortfin eel	Longfin eel
Number of fish	20	36	2	0	1	0	0	0
Size range (mm)	38-100	47-76	66-145		37			

Figure 9. Fish recovered from within the remediated culvert at the conclusion of the monitoring.

Discussion

Interestingly, these results suggest that this structure was not a complete barrier to some fish species prior to remediation despite clear perches at both culvert outlets. Juvenile banded kokopu were found in both A-frame nets on day one of the trial before remediation had taken place. Furthermore, banded kokopu and shortfin eels were found to have negotiated the unremediated culvert at various times over the monitoring period. These fish were small, with the maximum fish length 45mm for banded kokopu and 60mm for shortfin eels. The exact pathways these fish took to gain access into the culverts is unknown, however observations have previously been made by the author at the same site in 2020 of fish climbing in the vicinity of the outlets, and opportunistically using a buildup of moss and algae to move into the culvert pipes (Figure 10). Similar opportunities were absent from the culvert outlet during the entirety of this trial; therefore, it is assumed the fish that successfully transitioned prior to the remediation, and via the unremediated culvert, did so by climbing under and around the undercut and moving past the slightly rounded culvert lip. Evidence of other pathways, including between cracks or joins in the culvert pipes were not identified, however one can never rule out the possibility of fish utilising these areas given the opportunity. The small body size of the fish caught prior to remediation, and in the unremediated culvert net throughout the study, likely allowed for greater passage success when climbing up under the pipe undercut.

Figure 10. Banded kokopu juvenile climbing up a build-up of moss and algae at Williams Road in 2020

Following remediation, a small but steady number of banded kokopu were caught daily during the first half of the trial (up till day 12) in the remediated culvert net, but only intermittently caught in the unremediated culvert net. Inanga and shortfin eels were occasionally represented in the catch during this time with the former only in the remediated culvert net, and the latter only in the unremediated net (Figure 11). Numbers of fish caught in the second half of the trial increased in an upward trend in the remediated culvert net, but tended to drop away in the unremediated culvert net. The last day of the trial (day 23) saw the highest number of fish caught in the remediated culvert net, a total of 14 fish. Four species of fish were caught between day 12 and day 23 including banded kokopu, inanga,

shortfin, and longfin eels with inanga, shortfin and longfin eels only transitioning via the remediated culvert.

Figure 11. An inanga captured on day 6

Rainfall and increased flows may have encouraged fish movement into the remediated culvert in the later stages of the trial. A fresh occurred on day 19. Fish were observed using the flexible rubber ramp during these elevated flows. Three pathways on the ramp were used, on the wide wetted margins (Figure 12), adjacent to the mussel-rope bundle within the water column, and within the mussel-ropes themselves (Figure 13). Fish using the areas adjacent to the mussel-rope bundles were only seen for brief moments and whether they were successful in moving into the culvert is unknown. One juvenile galaxiid was seen successfully moving into the remediated pipe on the true right-hand wetted margin of the ramp on day 19 (Figure 12).

The remediated culvert appears to allow passage for a range of fish sizes, including larger individuals. Of the fish species represented in both culvert nets (banded kokopu and shortfin eels), larger fish were captured in the remediated culvert net. Banded kokopu lengths ranged from 33-80mm, and shortfin eels lengths ranged from 56-80mm in the remediated culvert net. The range narrows for fish caught in the unremediated net with banded kokopu lengths ranging between 35-45mm and shortfin eels between 56-60mm.

Figure 12. Juvenile galaxiid transitioning into the pipe via the true right wetted margin (yellow circle)

Figure 13. Juvenile galaxiid observed within the mussel-rope bundle (yellow circle)

A large number of fish were caught within the remediated culvert at the conclusion of the trial. 58 fish were recovered including 36 inanga. Schools of galaxiid, some 20+ fish strong, were observed schooling around the remediation pipe inlet for several days prior to the trial conclusion. These fish were observed moving back and forth between the culvert pipe and the mouth of the A-frame net suggesting a possible disinclination to progress upstream into the net. If the A-frame nets at the top of the pipes were discouraging fish from moving into the “no return” area of the net, then this may explain the accumulation of fish within the barrel.

Habitat within the remediated culvert may have also been favourable to fish. The use of flexible baffles aimed to create in pipe habitat in the form of a series of pools and by retaining bed material. Other than some minor gravel deposits between some of the baffles, bed material within the pipe was absent at the conclusion of the experiment. Pools between baffles were evident however, and galaxiids were observed feeding upstream of the topmost baffle on several occasions (Figure 14). Furthermore, the overhead cover created by the culvert may have added a sense of security to the fish within, where the habitat would have been void of large predators such as eels or birds. If fish were successfully feeding within the culvert, and the habitat within the culvert was favourable, there may not be a physical requirement or desire for a fish to continue moving upstream at least over the short term.

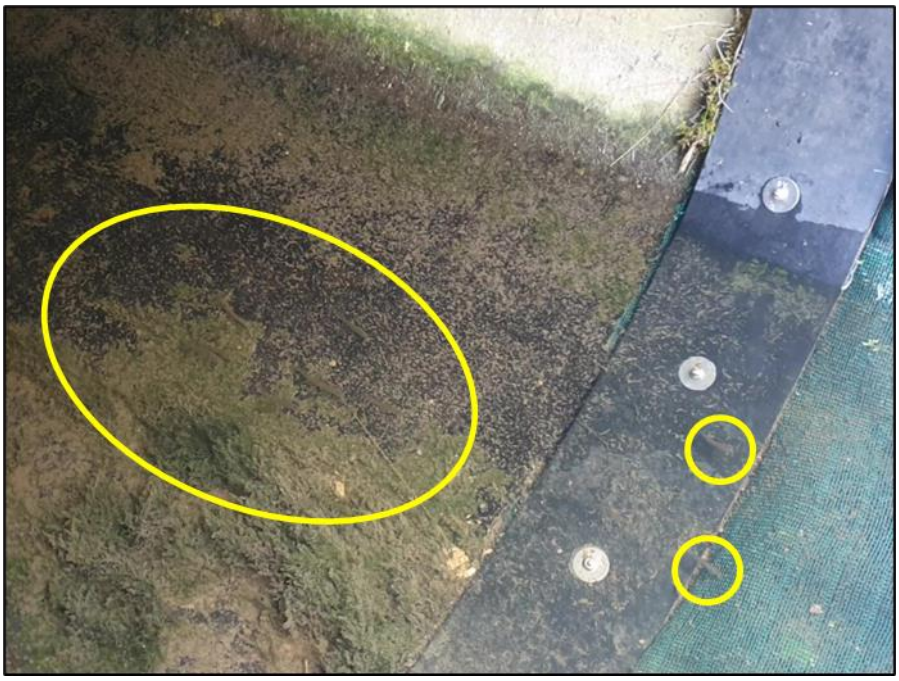


Figure 14. Schools of galaxiid feeding upstream of the topmost baffle (yellow circles)

eDNA sampling suggests that prior to remediation the only species able to move past the Williams Road culvert were banded kokopu, longfin eels and shortfin eels. It should be noted that only three replicates were deployed. Current “best practice” advises six replicates to confidently identify all species present. eDNA sampling post remediation has identified three new species upstream of the culvert including redfin bully, inanga and giant kokopu.

Conclusion

Remediating the Williams Creek culvert with a flexible ramp with looped mussel-rope and flexible fish baffles has improved passage for three species of fish, banded kokopu, inanga, and longfin eel.

Inanga and longfin eels only moved through the remediated culvert.

Banded kokopu moved through both culverts, but nearly five times as many moved through the remediated culvert compared to the unremediated culvert.

A similar number of shortfin eels passed through both culverts.

Additionally, eDNA sampling suggests the remediation may also allow passage for redfin bully, inanga and giant kokopu.