Christchurch Fish Barriers Update

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Prepared for:
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EXECUTIVE SUMMARY

New Zealand's freshwater fish fauna includes many diadromous species, requiring passage to and from the ocean to complete their life histories. Artificial instream structures, including culverts, weirs, and flap gates, have the potential to disrupt migration paths, placing pressure on migratory fish populations. To address this issue in the Christchurch district, Christchurch City Council (CCC) commissioned a barrier prioritisation project in 2021. The product of this project was a database of structures in the district with priorities for either: fish barrier assessment (identifying structures of perceived risk); fish surveys (quantifying the impact of high risk structures when local fishing data was inadequate); or, when information on structure risk and local fish communities was adequate, remediation. The current report describes an update to this database, including a summary of the summer 2021–22 round of barrier assessments and fish surveys, which were used to re-run the CCC barrier prioritisation model.

The updated prioritisation database includes approximately 2,600 potential barriers, of which, some 1,300 were identified as CCC assets. Of the CCC owned structures, 11 were identified as a high priority for remediation (compared with eight prior to the update) and a further two were a high priority for fish surveys (compared with 12 prior to the update). There were no remaining CCC assets that were a high priority for barrier assessments. A further 17 structures were identified as high priority for either remediation or fish surveys but were not identified as CCC assets. Most of these structures were listed in the database as being of unknown ownership, however, some of these structures are suspected to be CCC assets and require ownership review.

By design, the current prioritisation model places a heavy focus on CCC's nine priority catchments, these generally being catchments with a high level of biodiversity value or stakeholder interest. Structures beyond these catchments are assigned a limited priority for remediation. However, such structures may still be ecologically significant barriers. The Mona Vale weir was recognised as an ecologically significant barrier outside of the priority catchments during the 2021 prioritisation project. As such, the weir has been scheduled for replacement with a lower risk rock riffle. Examination of the new prioritisation database suggests that this remediation will unlock 1–3 km of uninterrupted aquatic habitat, i.e., before the next high risk barrier, in the Avon River, Wairarapa Stream, and Waimairi Stream waterways. A further 31 CCC assets were identified outside of priority catchments that received equal remediation priority scores as the Mona Vale weir, the remediation of which may also provide positive ecological outcomes.

Based on the results of the updated prioritisation database, we recommend the following: investigation into remediation options for the 11 CCC structures that are a high priority for remediation; carry out fish surveys in relation to the two CCC structures that are high priorities for fishing; FPAT assessments of further council culverts, beginning with Banks Peninsula where high risk culverts are common; review ownership of the 14 high priority structures for fishing or remediation that are not recognised as CCC assets in the databases we used; and consider revising the prioritisation model to allow for ecologically significant barriers beyond priority catchments to receive high priorities for remediation.

1. INTRODUCTION

New Zealand's freshwater fish fauna includes many diadromous species, requiring passage to and from the ocean to complete their lifecycle. Migration paths of these species may be blocked by artificial instream structures, most commonly including culverts, weirs, or flap gates. These barriers place additional pressure on New Zealand's migratory freshwater fish species, many of which are already 'threatened' with extinction, or 'at risk' of becoming so (Dunn *et al.* 2018).

The importance of this issue is acknowledged in the National Policy Statement for Freshwater Management 2020 (NPSFM; Ministry for the Environment 2020). Under the NPSFM, regional councils must develop a work programme for the remediation of instream structures. Briefly, this work programme must include identification of barriers, evaluation of their risk to fish passage, and prioritisation of structures for remediation. To help satisfy these requirements, Christchurch City Council (CCC) commissioned a study in 2021 to assess barriers in the Christchurch district and to prioritise them for further investigation or remediation (Instream Consulting 2021).

Briefly, the initial prioritisation project built on the Fish Passage Assessment Tool (FPAT; Franklin 2018) database. The FPAT allows for structures to be field assessed for risk to fish passage through a standardised assessment process. A calculated structure risk is then combined with spatial components relating to the distance to coast, proximity of other barriers, and upstream catchment size, to produce an FPAT prioritisation for remediation. All this information is then recorded in a publicly accessible digital database.

By combining the FPAT database with CCC asset information, the prioritisation project identified CCC assets that had been FPAT assessed, and those that were a priority for assessment. For structures with FPAT assessments, local fish records were examined and if the information on the surround fish community was adequate, they were assigned a priority for remediation. If fishing information was inadequate, structures were assigned a priority for fish surveys. The final product of the prioritisation project was a georeferenced database containing structures (including CCC and non-CCC assets), each with an assigned alphanumeric code. The code referred to the next action, this being either an FPAT Assessment (A), a Fish survey (F), or Remediation (R), and a priority ranging from 1 (low priority) to 5 (high priority).

This report describes results of an update to the CCC barrier prioritisation database. The update is based on barrier assessments and fishing undertaken by Instream over summer 2021–22, all new assessments in the FPAT database, and all new fish records from the New Zealand Freshwater Fish Database (NZFFD; Richardson 2005). Using the updated database, high priority CCC structures are identified and briefly discussed, and recommendations are made on future actions to enhance fish passage in the district.

2. METHODS

2.1. Summer 2021–22 Barrier Assessments

A total of 61 structures were selected by CCC to be FPAT assessed over the summer of 2021–22. Of this number, 26 were structures that had been previously identified as high priority for assessment during the initial prioritisation project. The remaining 35 structures were from the Ōtākaro/Avon River catchment, including structures (mostly culverts) in the Avon River mainstem, Waimairi Stream, Wairarapa Stream, and Okeover Stream. These structures were assessed to provide information on the quantity of accessible aquatic habitat that could potentially be opened by the remediation of the Mona Vale weir, which is scheduled for fish passage improvements in the near future.

Briefly, the FPAT assessments involved summer students visiting the structures and recording a variety of measures relevant to fish passage, via the FPAT mobile application (Franklin 2018). Measurements either related directly to the structure (e.g., length of culvert, height of weir) or to the surrounding waterway (e.g., width of stream, water velocity). Photographs were taken at both the upstream and downstream ends of the structure, including at least one photograph of the upstream and downstream aquatic habitat. Surveyors also recorded any additional notes in relation to fish passage or aquatic habitat in the FPAT application. FPAT surveys were reviewed for accuracy by Instream staff prior to their upload into the FPAT database. Previous experience showed that the value of FPAT assessments was greatly improved with good photographs, site descriptions, and quality checks by ecologists.

Of the 61 structures selected for assessment, 52 resulted in complete FPATs. The remaining structures were either: not located (five structures), too deep to assess but of no risk to passage (two structures), falsely attributed a high priority in the initial study (one structure), or removed from the database prior to assessment as the catchment upstream was piped (one structure).

2.2. Barrier Fishing

All barrier fishing was carried out over the summer of 2021–22, from December through to April.

A total of 14 structures were selected by CCC to receive fish surveys (Figure 1 and Table 1). Of these structures, 13 were selected as they had been identified as high priorities during the initial prioritisation project. Following interest from Ngāti Wheke Hapū, an additional culvert in Omaru Stream (which flows near the Rāpaki marae) was added to the list of structures to be fished. The purpose of these fish surveys was to identify the fish communities that could be affected by artificial barriers and to use this information to guide remediation prioritisation.

Following the discovery of a 6 m vertical waterfall 40 m downstream of the Raupō Stream culvert in Raupō Bay, the fish survey at this site was abandoned. The justification for this was that any species capable of ascending the waterfall would have no problem passing the culvert. Therefore, fish surveys were competed at 13 structures.

At each structure, a default of two reaches was sampled: one upstream and one downstream of the structure. Downstream fishing was not possible for two flap gates at the end of Charlesworth Drain and Rifle Range Waterway, which discharge directly into the Estuary of the Heathcote and Avon Rivers / Ihutai. Additional survey reaches were included at other sites

when there were additional structures near the structure of interest (upstream or downstream) that may impact fish passage.

Fishing methods varied among sites, depending on what was most appropriate for the conditions present (Table 1). We generally used fine mesh fyke nets and Gee minnow traps for waterways that were deep, slow, and/or had soft beds. The number of nets and traps was generally determined by the amount of aquatic habitat available. We used electric fishing to sample fish communities at locations with shallower and swifter flows, and/or stony. For electric fishing, a minimum of 50 m of waterway length and 50 m² was sampled for each reach. Reaches were extended if the fish catch was particularly low, with the aim of catching all species present. While fishing methods varied between sites, methods were standardised between reaches upstream and downstream of the structures, when possible. This allowed for direct comparisons of the fish populations upstream and downstream of structures.

All fish caught were identified to the species level when possible, counted, and the first 50 individuals of each species was measured. Eels were anesthetised in an ethanol-clove oil solution to aid in their measurement. Anesthetised fish were allowed to recover in bins, before all caught fish were returned to their resident habitats.

At a representative location near each structure a NZFFD card form was completed. Briefly, these forms record a variety of general habitat measurements relating to physical waterway attributes (e.g., widths and depths), fish cover features (e.g., presence of macrophytes or undercut banks), and water physiochemical properties (e.g., temperature and dissolved oxygen). Any additional observations relating to fish or habitat conditions were also recorded by surveyors. This data was then submitted to the NZFFD.

A relevant fish survey carried out by Burrell (2022) in Rifle Range Waterway was also added to the data and is included in Table 2 (Structure 2: Upstream 2).

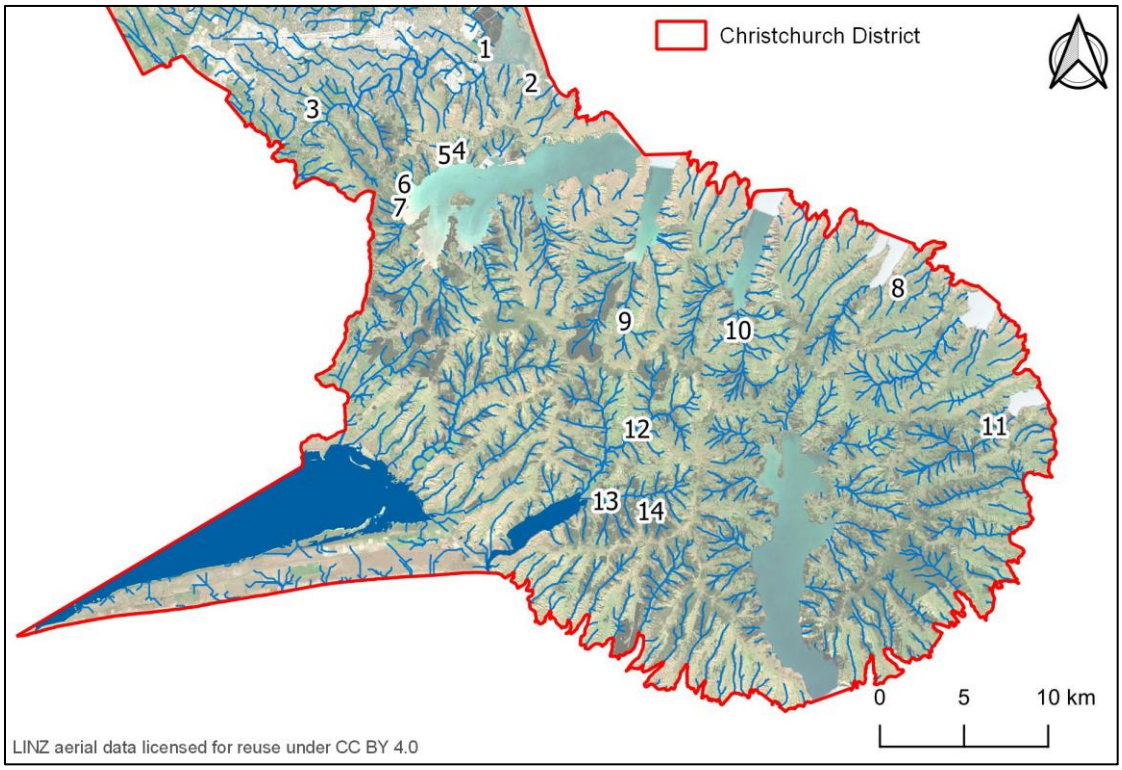

Figure 1: The locations of the structures that received fishing surveys.

Table 1: Fish sampling locations and associated instream structures, ordered from north to south.

Structure Number	Waterway (Catchment)	Easting	Northing	Structure type	FPAT ID	CCC ID	No. Sites[1]	Reach and Methods[2]
1	Charlesworth Drain (Estuary)	1576544	5178346	Flap gate & culvert	136467	SwValve 501	1	Upstream 1: one coarse mesh fyke net and eight GMT
2	Rifle Range Waterway (Estuary)	1579282	5176321	Flap gate & culvert	134912	SwValve 306	2	Upstream 1: EFM (55 m²) Upstream 2: Six GMT (Burrell 2022)
3	Miln Drain (Cashmere Stream)	1566304	5174775	Other	130166	SwPipe 87535	2	Downstream 1: Five fine mesh fyke nets Upstream 1: Five fine mesh fyke nets
4	Cass Bay Drain (Cass Bay)	1574993	5172307	Weir	317	SwPipe 96452	3	Downstream 1: Two GMT Downstream 2: Five GMT Upstream 1: Five GMT
5	Omaru Stream (Rāpaki Bay)	1574118	5172053	Culvert	1873	SwPipe 58275	4	Downstream 1: Six baited GMT Downstream 2: Six baited GMT Downstream 3: Six baited GMT Upstream 1: Six baited GMT
6	Stream Reserve Drain (Governors Bay)	1571742	5170327	Culvert	134866	SwPipe 76048	2	Downstream 1: EFM (63 m²) Upstream 1: EFM (59 m²)
7	Church Lane Drain (Governors Bay)	1571477	5168934	Culvert	286	SwPipe 76008	3	Downstream 1: Five GMT Downstream 2: Five GMT Upstream 1: Five GMT
8	Raupō Stream (Raupō Stream)	1601082	5164156	Culvert	1105	SwPipe 60656	0	Not fished due to 6 m waterfall observed 40 m downstream of culvert
9	Owhetoro Stream Branch No 4 (Owhetoro Stream/ Port Levy)	1584853	5162183	Culvert	1194	SwPipe 59843	2	Downstream 1: EFM (132 m²) Upstream 1: EFM (140 m²)
10	Totara Stream (Pigeon Bay Stream)	1591569	5161650	Culvert	1050	SwPipe 60168	2	Downstream 1: EFM (80 m²) Upstream 1: EFM (50 m²)
11	Le Bons Stream Branch No 13 (Le Bons Stream)	1606808	5155964	Culvert	1326	SwPipe 61976	2	Downstream 1: EFM (70 m²) Upstream 1: EFM (70 m²)
12	Opuahou Stream Branch No 14 (Lake Wairewa/Forsyth)	1585556	5155791	Culvert	295	SwPipe 58366	3	Downstream 1: EFM (91 m²) Upstream 1: EFM (66 m²) Upstream 2 EFM (Not recorded)
13	Kinloch Stream (Lake Wairewa/Forsyth)	1583692	5151522	Culvert	1234	RAMM W17	3	Downstream 1: EFM (75 m²) Upstream 1: EFM (96 m²) Upstream 2: EFM (95 m²)
14	Okuti River Branch No. 9 (Lake Wairewa/Forsyth)	1586351	5150936	Weir & culvert	278	RAMM W11	2	Downstream 1: EFM (169 m²) Upstream 1: EFM (169 m²)

Notes: [1] Indicates the number of sampling reaches surveyed. [2] 'Upstream' and 'Downstream' indicates where the sampling reach is in relation to the structure of interest. When additional reaches were sampled, these are numbered from downstream to upstream, e.g., Upstream 2 > Upstream 1 > Structure of interest > Downstream 2 > Downstream 1 > Ocean. GMT = Gee Minnow Trap. EFM = Electric Fishing Machine. For EFM reaches, the area fished is included in brackets.

2.3. Barrier Prioritisation Update

Barrier prioritisation followed the same general methodology and decision tree (Figure 2) as that of the original CCC prioritisation project (Instream Consulting 2021), and any differences are described below. The CCC priority catchments have remained unaltered since the initial project, and include the Ōtūkaikino, the Pūharakekenui (Styx River), Cashmere Stream, Whakaraupō (Lyttleton Harbour), Wairewa (Lake Forsyth), Peraki Bay, Wainui Bay, Takamatua, and Ōkaruru.

The database was updated to include all new FPAT assessments and with information from all new NZFFD fish records in the Christchurch district, up until 1 June 2022. A total of 159 new FPAT structure assessments were added to the prioritisation database, 52 of which were associated with the summer 2021–22 barrier assessments. A further 51 assessments were associated with stormwater pond structures, relating to a CCC project on fish populations in such facilities (Instream Consulting 2022). The remaining 56 new assessments were carried out either by consultancies or by ECan and were associated with various unrelated projects.

Structures associated with stormwater facilities with an entirely piped network upstream (i.e., 'offline' facilities) were not prioritised for remediation, and were instead assigned the code 'OS' (Offline Stormwater; 30 structures). These structures were not assigned a remediation priority because the ecological merit of providing fish passage into a facility designed to trap pollutants is questionable, especially if there is no aquatic habitat upstream (Instream Consulting 2022). Further information on the effects of stormwater habitats on fish health is required to inform remediation priorities for offline stormwater facilities. For stormwater facilities with open waterways upstream (i.e., 'online' facilities), structures were assigned a priority as per usual.

All structures with new FPAT assessments were automatically assigned priorities for either remediation or fish surveys, via a decision tree model (Figure 2). Each of the structures was then reviewed manually, and adjustments were made to the priorities when appropriate. Examples of factors that justified adjusting the priorities included: waterway dry or low flow (reduce priority), significant barrier downstream (reduce priority), or large upstream catchment (increase priority). This was consistent with the methodology of the initial prioritisation project.

All existing structures in the CCC prioritisation database were also updated with any new information. This included checking all structures for changes in their FPAT priority scores and for any new relevant fish records in their respective catchments, as this would affect the decision tree model (Figure 2). The automatic priorities were then updated for the 31 affected structures and manual review of their priorities was carried out.

During the initial prioritisation project 38 CCC assets were identified as high priorities for FPAT assessment, but were unable to be assessed, generally either due to lack of safe accessibility or structures being underground. These structures were reviewed in the office in consultation with CCC engineers, and new priorities assigned.

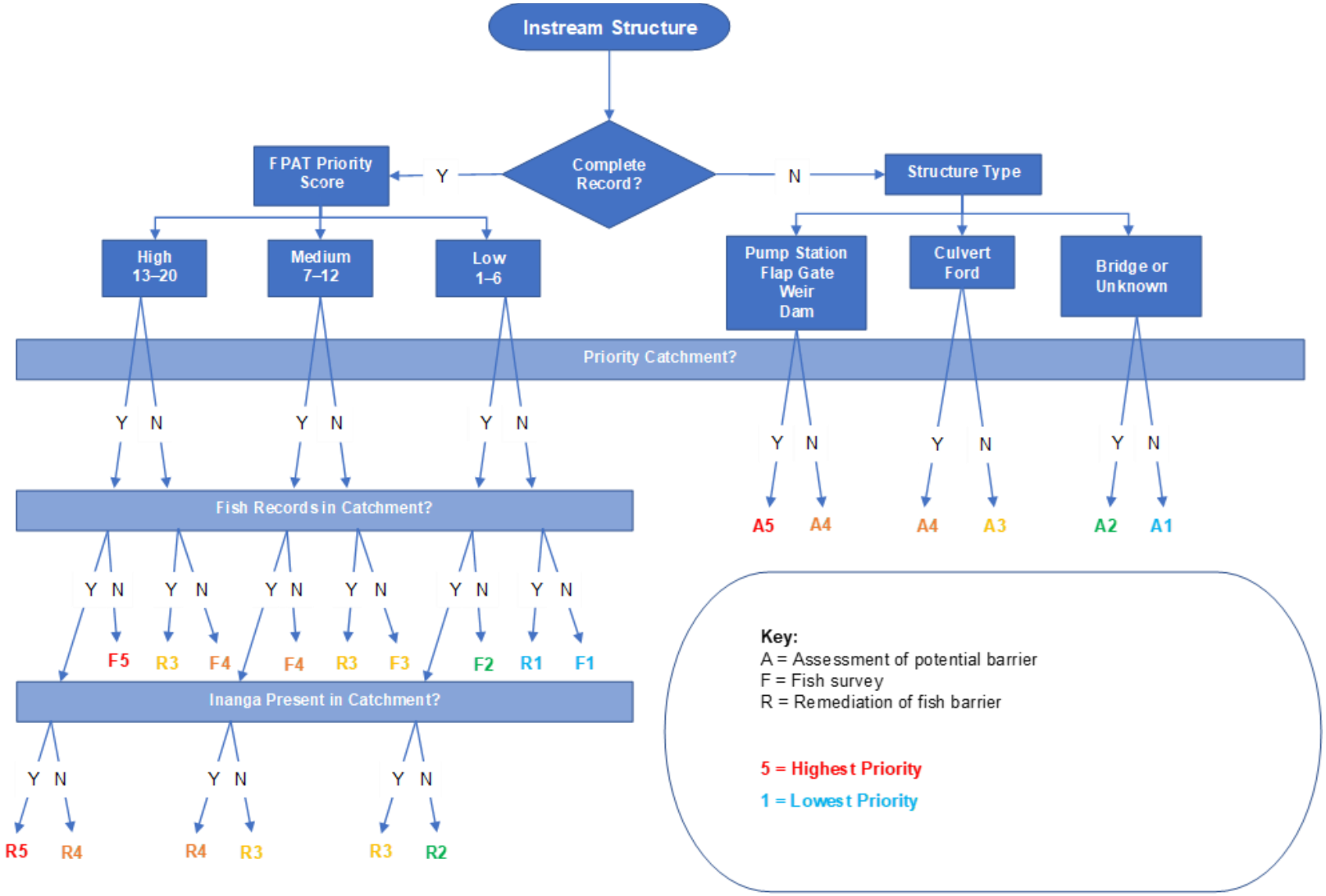

Figure 2: The decision tree model used to assign actions and priorities to structures in the prioritisation database, from Instream Consulting (2021). *Y=yes, N=no.*

3. RESULTS AND DISCUSSION

3.1. Barrier Fishing Results

Most of the fishing was undertaken in small hill-fed waterways in Banks Peninsula (Figure 1). These waterways often have low flow and some of the smaller streams can dry out over summer in low rainfall years. Some of the sampled waterways were dry during the two summers prior to our 2021–22 sampling. This includes Omaru Stream and Cass Bay Drain, and possibly other similarly-small waterways. The summer of 2021–22 was wetter than the previous two summers. However, some waterways remained dry for much of spring 2021, which will have limited the opportunity for recolonisation by juvenile fish. It is therefore likely that fish communities are still recovering from previous dry conditions and our fishing results may underestimate the abundance and diversity of fish species normally present.

A total of 11 species were caught during the barrier fishing surveys, including 10 native and one exotic species (Table 2). All but two of the caught species were diadromous. Four At Risk species were caught, including longfin eel, bluegill bully, inanga, and kōaro (Dunn et al. 2018). Lamprey was the only threatened species caught, recorded only in one location (Kinloch Stream). Longfin and shortfin eels were the most widespread species, being found in most of the surveyed waterways. Inanga was also widespread, but less abundant. However, abundant juvenile galaxiids were recorded in Le Bons Stream Branch No 13, and it is likely that many of them were juvenile inanga. Photographs of some of the native species caught are shown in Figure 3.

Table 2: Fish species caught during the barrier fish surveys, including the number of sites they were caught at (No. Sites), and total number caught. Table ordered by total catch. Non-diadromous species are indicated with an asterisk. Threat statuses are from Dunn *et al.* (2018).

Species	Common Name	Threat Status	No. Sites	Abundance
Anguilla australis	Shortfin eel	Not Threatened	10	225
Anguilla dieffenbachii	Longfin eel	At Risk - Declining	7	48
Galaxias maculatus	Inanga	At Risk – Declining	6	19
Anguilla spp. (elver)	–	–	5	25
Galaxias fasciatus	Banded kōkopu	Not Threatened	4	57
*Gobiomorphus breviceps**	Upland bully	Not Threatened	4	72
Gobiomorphus cotidianus	Common bully	Not Threatened	4	20
Gobiomorphus sp. (juvenile bully)	–	–	4	85
Galaxias brevipinnis	Kōaro	At Risk – Declining	2	15
Galaxias sp. (juvenile galaxiid)	–	–	2	440
Gobiomorphus huttoni	Redfin bully	Not Threatened	2	25
*Salmo trutta**	Brown trout	Introduced and Naturalised	2	41
Geotria australis	Lamprey	Threatened – Nationally Vulnerable	1	69
Gobiomorphus hubbsi	Bluegill bully	At Risk - Declining	1	4

Figure 3: Examples of some of the fish species caught during the surveys. Clockwise, beginning in the top left, they include: a kōaro from Okuti River Branch No. 9, a banded kōkopu from Stream Reserve Drain, two inanga from Miln Drain, and a longfin eel, also from Miln Drain.

Fish were caught in all surveyed waterways, and the greatest diversity of species and number of individual fish were caught in Le Bons Stream Branch No 13 (Table 3). High fish numbers were recorded at most sites, with seven of the 13 fished waterways recording >25 individuals. When low fish numbers are recorded it is difficult to infer a barrier effect, conversely, when fish numbers are high, barrier impacts should be clear. Furthermore, structures impacting higher numbers of individuals should be considered a higher priority for remediation.

Table 3: Number of species and total fish by site. Table ordered by number of fish species. Note that fishing method and effort differed among sites, as per Table 1.

Structure Number	Waterway	Species	Abundance
11	Le Bons Stream Branch No 13	6	503
13	Kinloch Stream	6	158
10	Totara Stream	5	45
3	Miln Drain	4	206
12	Opuahou Stream Branch No 14	4	87
7	Church Lane Drain	4	13
6	Stream Reserve Drain	3	39
2	Rifle Range Waterway	3	26
4	Cass Bay Drain	2	24
14	Okuti River Branch No. 9	2	16
9	Owhetoro Stream Branch No 4	2	15
1	Charlesworth Drain	1	11
5	Omaru Stream	1	2

A complete summary of the barrier fishing catch is tabulated in Appendix 1, and photographs of the structures and survey reaches are provided in Appendix 2. The following paragraphs briefly summarise meaningful results from the fish surveys. Surveyed structures not discussed below either had low fish numbers, no patterns between the upstream and downstream populations that would indicate a high risk to fish passage, low upstream habitat potential, or had other substantial barriers downstream.

Structure 3, Miln Drain: Shortfin eel numbers were reduced upstream (50 individuals) when compared with downstream (103 individuals). Five inanga were recorded downstream of the structure but none were recorded upstream. These results confirm that the structure is a high risk to fish passage and is impacting the distribution of native fish in the catchment.

Structure 6, Stream Reserve Drain: Banded kōkopu were recorded in reduced numbers upstream of the culvert (eight individuals) when compared with downstream (21 individuals). A slight reduction in shortfin eel abundance was also recorded, with six individuals caught downstream of the culvert compared to the three individuals upstream. A single redfin bully was also caught downstream end of the culvert, with no redfin bully caught upstream. These results confirm that the structure is a high risk to fish passage and is impacting the distribution of native fish in the catchment.

Structure 10, Totara Stream: The surveyed fish population around the culvert in Totara Stream had high species diversity, with five species recorded. While the structure appeared to be passable by shortfin and longfin eel, the remaining three species were only caught at the downstream site. These species included common bully, upland bully, and inanga (At Risk – Declining; Dunn *et al.* 2018), all of which were recorded in low densities (1–3 individuals per species). These results confirm that the structure is a high risk to fish that are weak climbers and that it is impacting the distribution of native fish in the catchment.

Structure 13, Kinloch Stream: The culvert in Kinloch Stream appeared to be unpassable by common bullies, with 11 individuals recorded downstream and none recorded upstream. Brown trout numbers were reduced upstream, with 15 individuals recorded downstream of the culvert and 10 upstream. Juvenile lamprey (ammocoetes) were abundant above the culvert, totalling 67 individuals, with only two individuals caught downstream. The difference in lamprey density was attributed to a greater proportion of soft sediments upstream of the culvert, which is the preferred habitat of ammocoetes. Lamprey have a Threatened – Nationally vulnerable conservation status (Dunn *et al.* 2018), and Kinloch Stream is one of the few locations where lamprey spawning has been observed in New Zealand (Baker *et al.* 2017). We do not recommend altering fish passage at the structure, given the presence of threatened lamprey upstream, and given that the structure may be providing some protection from predation and competition with other species.

Structure 11, Le Bons Stream Branch No 13: The sampled fish community around the culvert in Le Bons Stream Branch No 13 was the most abundant and diverse of any of the sampled waterways (Table 3). Of the six species caught, three have a conservation status of At Risk – Declining, including: longfin eel, bluegill bully, and inanga (Dunn *et al.* 2018). The culvert was perched at the time of sampling and has the potential to affect fish distributions. Of the six species recorded downstream, all but two were found upstream. The two species not recorded upstream were shortfin eel and banded kōkopu. The juveniles of these two species are exceptional climbers and it is very unlikely that the structure was responsible for their absence upstream. Species recorded both upstream and downstream of the structure included inanga, which are poor climbers, and several bully species, which are not strong climbers. Therefore, despite the observed potential barrier to fish passage, it does not appear to be significantly affecting fish distributions. Thus, we do not consider the structure a high priority for remediation.

Stormflows may be an opportunity for upstream migration for some individuals, but they also represent a disturbance event. A particularly large storm event occurred around Banks Peninsula during December 2021, about a month prior to the fish survey, resulting in severe flooding of streams in the Le Bons Bay area. A small number of the larger banded kōkopu caught during the survey in Le Bons Stream Branch No 13 had signs of damage and infection, which may have been caused by the storm event (Figure 4).

Figure 4: Two large banded kōkopu with signs of injury and infection.

3.2. Barrier Prioritisation Update

A total of 2,564 structures were included in the updated barrier prioritisation database, including 1,312 structures that were associated with CCC assets (Table 4). Of the CCC assets, 199 (15%) structures were assigned remediation priorities ('R'; FPAT assessed with adequate fish data), 241 (18%) were assigned fishing priorities ('F'; FPAT assessed but lacking fish data), and 843 (64%) were assigned assessment priorities ('A'; not FPAT assessed). The remaining 843 unassessed CCC assets include bridges, culverts not in priority catchments, and assets with unknown structure types. Such structures were deemed to be a lower priority for assessment during the initial prioritisation study. An additional 29 (2%) CCC structures were associated with offline stormwater facilities ('OS') and were not prioritised for further action, as per Section 2.3 above.

Table 4: The number of structures in each of the prioritisation categories, after updating the prioritisation database.

Priority[1]	CCC Owned	Other / Unknown Ownership	Total
R5	4	0	4
R4	7	3	10
R3	31	19	50
R2	26	14	40
R1	131	74	205
F5	0	5	5
F4	2	9	11
F3	44	17	61
F2	56	25	81
F1	139	109	248
A5	0	37	37
A4	0	141	141
A3	552	167	719
A2	64	160	224
A1	227	471	698
OS	29	1	30
Total:	**1,312**	**1,252**	**2,564**

Note: [1] 1 = low priority, 5 = high priority, 'R' = Remediation, 'F' = Fish survey, 'A' = FPAT Assessment, 'OS' = Offline Stormwater structure.

A total of 11 CCC assets received high remediation priorities (R5 or R4) and two received high fish survey priorities (both F4; Table 5). By comparison, the previous prioritisation study identified eight CCC structures that were a high for remediation and 12 structures that were high priorities for fish surveys (Instream Consulting 2021). Of the 13 high priority structures presented in Table 5, eight were identified during the previous prioritisation study, and there has been no change to their priorities. A further two structures were identified as high priorities for fishing in the previous prioritisation study, but their status has now changed to being high priorities for remediation, based on the results of the summer fishing. The remaining three structures were identified as high priorities during this prioritisation update. There are no remaining CCC assets in the database that are a high priority for FPAT assessment. This reflects the summer 2021–22 barrier assessment efforts, which targeted such structures. The focus of future FPAT assessments should now be shifted to the 552 CCC owned 'A3' priority structures, i.e., culverts that are outside of priority catchments.

Three structures were identified as high priorities for remediation (all R4) and 14 were high priorities for fish surveys (F5 or F4), but were not associated with CCC assets (i.e., other or unknown ownership; Table 4). While these structures were not associated with CCC assets during the initial prioritisation project, it has come to our attention that some of the structures are of CCC ownership. During the initial project, CCC assets were associated with FPAT assessment based on CCC 'StormWater' and 'WaterCourse' GIS layers, provided by the council. In the time since this project, we have become aware that there is information on CCC assets relevant to fish passage beyond the stormwater and watercourse layers. For example, asset information on weirs associated with water takes can be found in the 'WaterSupply' layers. While further review of the ownership status of FPAT assessed structures is beyond the scope of the current study, we recommend that high priority structures of unknown ownership are reviewed against all CCC asset layers. The details of these structures are provided in Appendix 3. Such asset layers should also be interrogated to identify if there are any further CCC assets that are a high priority for FPAT assessment.

Table 5: All high priority (R5, R4, F5, and F4) structures owned by CCC, updated from Instream Consulting (2021). Structures are ordered firstly by action (i.e., Remediation or Fishing) and secondly by priority score. Structures with the same priority score have been ordered from highest priority to lowest priority, based on expert ecology judgement and local knowledge. The CCC Asset refers to the relevant GIS layer and asset number of each structure. Structures that have changed in priority since the initial prioritisation project are indicated in bold.

Waterway (Catchment)	FPAT ID	Structure Type	CCC Asset	Priority Score	Comments	Photographs
Ōtūkaikino Creek (Ōtūkaikino Creek)	130047	Weir	WcWeirs 199	R5	The most substantial barrier in the Ōtūkaikino catchment. Distribution of fish database records indicates that the structure is a total barrier for inanga. Velocities over fish ladder are too high for inanga.	
Takamātua Stream Branch No 7 (Takamātua Stream)	1411	Weir	Unknown	R5	Upstream of CCC bridge A33. A fish survey in 2020 identified abundant native fish downstream, including bluegill bully, redfin bully, longfin eel, and whitebait. No fish were caught upstream, confirming poor passage.	
Pūharakekenui / Styx River (Pūharakekenui / Styx River)	131907	Flap gate with culvert	WcValve 27	R5	High risk structure near the coast. Recommend an investigation into the gate's operation (opening frequency and duration) and impacts on fish movements and salinity (and associated implications for plant communities and inanga spawning).	
Wainui Valley Stream (Wainui Bay)	1140	Weir	WcWeirs 242	R5	ECan currently investigating fish passage enhancement options.	
Miln Drain (Cashmere Stream)	**130166**	**Other**	**SwPipe 87535**	**R4**	Fish surveys upstream and downstream of the structure indicated that this structure is substantial barrier to shortfin eels and inanga, as per the barrier fishing results discussed above.	
Okuti River Branch No 9 (Lake Forsyth (Wairewa))	278	Weir	RAMM W11	R4	Weir situated under bridge W11, but not listed in CCC weir database. Likely owned by CCC. Would need to remediate at the same time as another (presumably private) weir immediately downstream. Fish surveys upstream and downstream of the weirs indicate that the structures are substantial barriers for longfin eel and kōaro.	
Stream Reserve Drain (Lyttelton Harbour / Whakaraupō)	**134866**	**Culvert**	**SwPipe 76048**	**R4**	Fish surveys upstream and downstream of the culvert indicated that the structure is impacting fish passage, with reduced numbers of banded kokopu and shortfin eel caught upstream, as per the barrier fishing results discussed above.	
Carews Peek Stream Branch No 8 (Carews Peek Stream)	**143153**	**Culvert**	**SwPipe 59620**	**R4**	High risk culvert near the confluence with Carews Peek Stream mainstem. Longfin eels and kōaro have both been recorded downstream in the mainstem, but only shortfin eels have been caught upstream.	
Storer Diversion (Ōtūkaikino Creek)	130043	Culvert	SwPipe 46740	R4	There is another significant structure upstream (see next structure below). These would both need to be remediated to gain the full benefit. Structure would exclude most native species. Asset ownership is uncertain.	
Fisher Drain (Ōtūkaikino Creek)	130044	Pump station	WcWeirs 200	R4	Historical pump station (not in service) containing a substantial weir barrier. Gravity fed bypass ends in flap gates. Substantial culvert barrier downstream, these would both need to be remediated to gain the full benefit.	
Dunbar Waterway (Cashmere Stream)	132979	Culvert	SwPipe 45899	R4	We understand that realignments are proposed for sections of Dunbar Waterway and this structure may be scheduled for replacement, or within a section that is to be switched offline. This needs to be confirmed internally with CCC engineers	
Sheppards Drain (Pūharakekenui / Styx River)	**134654**	**Flap gate with culvert**	**SwPipe 37486**	**F4**	A high risk flap gate and culvert at the confluence between Sheppards Drain and the Styx River (Lower Styx Rd). The catchment upstream has high habitat potential, including the Sheppard Stream Reserve wetland. Targeted barrier fishing would confirm if this structure was negatively impacting fish passage.	
Church Gully Stream (Lyttelton Harbour / Whakaraupō)	**143258**	**Culvert**	**SwPipe 63196**	**F4**	The only known high risk structure in the catchment. Barrier fishing required to quantify the impact of this structure on fish passage.	

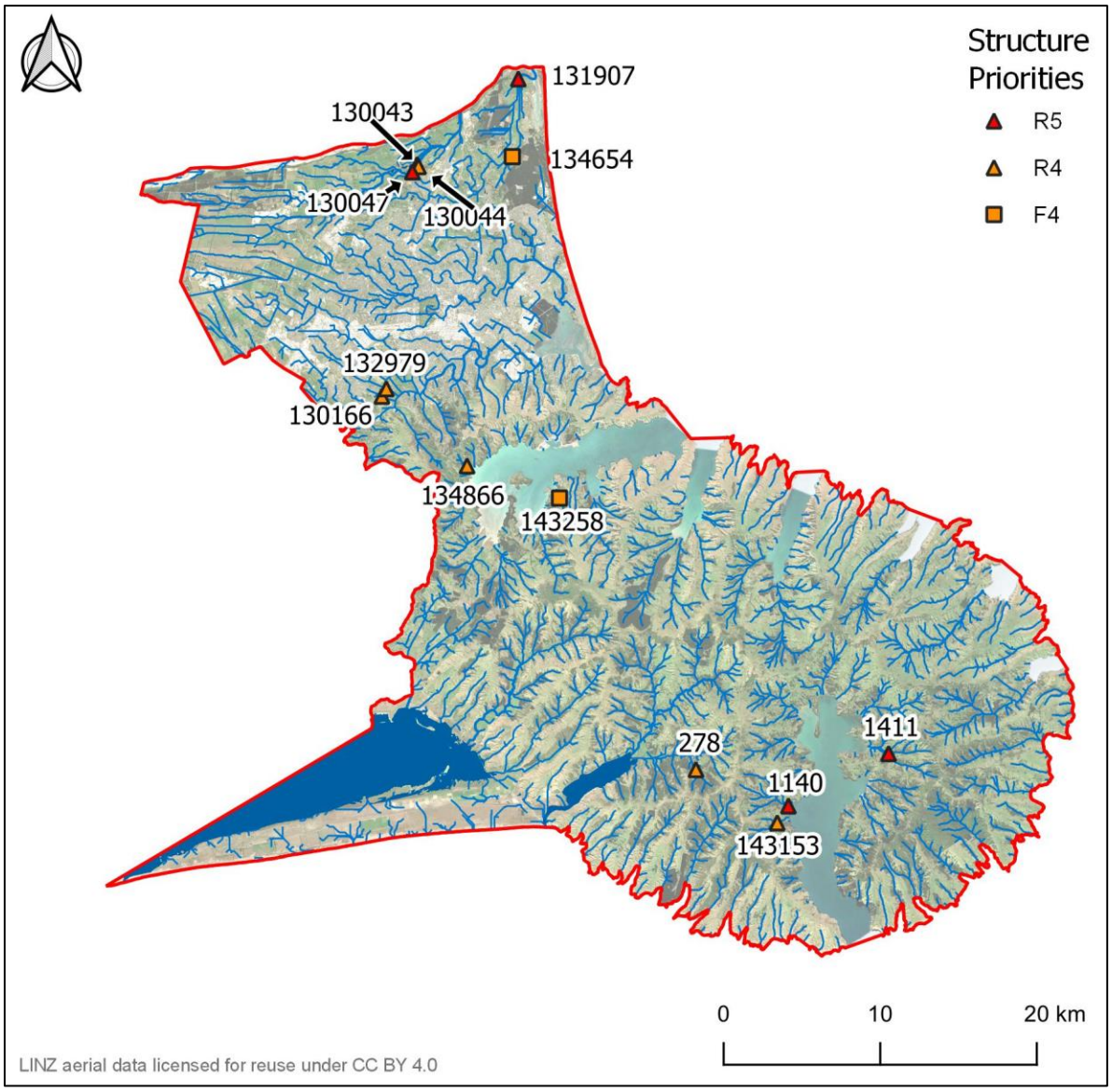

Figure 5: The location of CCC owned structures that are a high priority for remediation (R5 and R4) or fish surveys (F4). Structures labelled with their FPAT ID numbers.

By design, the current prioritisation model places a heavy weighting on CCC priority catchments. While this has been useful in providing a starting point for barrier remediation in the Christchurch district, focus on these catchments is expected to provide diminishing returns as fish passage issues are identified and remediated. Beyond the priority catchments there are potentially ecologically significant barriers that could be addressed. However, under the current model, barriers outside of priority catchments are limited to a maximum remediation priority of 'R3', a situation affecting a total of 31 CCC structures. We recommend considering a minor revision of the prioritisation framework to accommodate for ecologically significant structures, located outside of CCC's priority catchments. This would likely involve reviewing the 31 CCC assets in non-priority catchments currently assigned 'R3' priorities and creating a new high remediation priority category for those structures that are likely having substantial negative impacts on fish distributions.

The Mona Vale weir is an example of a very high risk structure that has an 'R3' priority. That is because the weir is not within a priority catchment, but it has previously been identified as an ecologically significant barrier (Instream Consulting 2021). Recognising the potential ecological benefits of remediating the weir, CCC has scheduled for the structure to be replaced with a lower risk rock riffle. This remediation will enhance passage to a large amount aquatic habitat upstream, with the next high or very high risk structures in Wairarapa Stream, Waimairi Stream, and the Avon River, being approximately 2 km, 3 km, and 1 km upstream, respectively.

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the results discussed above, the following conclusions and associated recommendations update those made previously by Instream (2021):

- Eleven CCC owned structures were identified as high or very high priorities for remediation.
  - Remediation options for these structures should be investigated and should incorporate knowledge of the local fish communities in the remediation design.
- Two CCC owned structures were identified as high priorities for fish surveys. Fish surveys should be carried out at these structures to quantify risks to fish passage and to identify any species-specific remediation design considerations. These structures include:
  - A culvert with a flap gate in Sheppards Drain (FPAT ID 134654)
  - A culvert in Church Gully Stream (FPAT ID 143258)
- FPAT assessments have now been completed of all high priority structures identified as CCC assets.
  - Future assessments should now focus on priority 'A3' structures, which are culverts outside of priority catchments. It may be most efficient to begin with culverts on Banks Peninsula, an area where culverts were previously identified as being a greater risk to fish passage (Instream Consulting 2021).
- CCC GIS layers should be reviewed to identify any layers with relevant asset information not currently included in the prioritisation database, such as the 'WaterSupply' layer. This review may yield further structures that are a high priority for FPAT assessment.
- There are 17 structures that are a high priority for either remediation or a fish survey, but have not been associated with CCC assets (Appendix 3). Some of these structures are known to belong to CCC.
  - A review of the ownership of these structures should be carried out to identify any further high priority CCC assets.
- The current design of the prioritisation model places a heavy weighting on CCC's priority catchments. Focus on these catchments is expected to provide diminishing returns as structures are assessed, surveyed, and remediated.
  - We suggest CCC consider a minor revision of the prioritisation model to better address fish passage issues outside of priority catchments. Logically, this process would begin with examining the 31 CCC assets outside of priority catchments with R3 (maximum remediation) priorities to assess the ecological merit of their remediation.

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APPENDIX 1: BARRIER FISHING CATCH TABLE

Table 1: The fish catch for each sampling reach, including abundance, and in brackets size (mm). Note that Site 8 was not fished and is therefore not included in this table. 'Upstream' and 'Downstream' location indicates where the sampling reach is in relation to the structure of interest. When additional reaches were sampled, these are numbered from downstream to upstream, e.g., Upstream 2 > Upstream 1 > Structure of interest > Downstream 2 > Downstream 1 > Ocean.

Structure Number	Site	Location	No fish caught	Longfin eel	Shortfin eel	Elver	Bluegill bully	Common bully	Redfin bully	Upland bully	Juvenile bully	Banded kokopu	Inanga	Kōaro	Juvenile galaxiid	Lamprey	Brown trout
1	Charlesworth Drain	Upstream 1			11 (168–630)												
2	Rifle Range Waterway	Upstream 1			9 (156–226)	5 (62–139)									1 (45)		
	Rifle Range Waterway	Upstream 2			4 (240–340)			1 (59)					6 (69–77)				
3	Miln Drain	Downstream 1		1 (535)	103 (217–780)					3 (42–54)	25 (20–31)		5 (79–129)				
	Miln Drain	Upstream 1		5 (557–1266)	50 (255–728)					3 (49–53)	11 (22–30)						
4	Cass Bay Drain	Downstream 1	No catch														
	Cass Bay Drain	Downstream 2										20 (55–132)	1 (66)				
	Cass Bay Drain	Upstream 1										3 (62–64)					
5	Omaru Stream	Downstream 1			2 (203–236)												
	Omaru Stream	Downstream 2	No catch														
	Omaru Stream	Downstream 3	No catch														
	Omaru Stream	Upstream 1	No catch														
6	Stream Reserve Drain	Downstream 1			6 (224–453)				1 (66)			21 (44–213)					
	Stream Reserve Drain	Upstream 1			3 (159–320)							8 (42–155)					
7	Church Lane Drain	Downstream 1			2 (362–407)			7 (75–107)				2 (75–97)	1 (75)				
	Church Lane Drain	Downstream 2	No catch														
	Church Lane Drain	Upstream 1			1 (440)												
9	Owhetoro Stream Branch No 4	Downstream 1		3 (277–479)	2 (151–156)	5 (95–135)											
	Owhetoro Stream Branch No 4	Upstream 1		3 (145–285)	2 (132–337)												
10	Totara Stream	Downstream 1		11 (231–947)	8 (190–378)	4 (115–145)		1 (89)		3 (56–65)			1 (64)				
	Totara Stream	Upstream 1		3 (195–521)	12 (153–422)	2 (97–109)											
11	Le Bons Stream Branch No 13	Downstream 1		4 (191–476)	8 (171–570)	5 (62–137)	2 (52–62)		4 (56–77)			3 (147–211)	3 (70–73)		231 (29–55)		
	Le Bons Stream Branch No 13	Upstream 1		6 (264–702)		3 (70–104)	2 (51–56)		20 (47–89)		2 (36–46)		2 (67–72)		208 (32–62)		
12	Opuahou Stream Branch No 14	Downstream 1		1 (559)		1 (126)					11 (15–23)						16 (44–79)
	Opuahou Stream Branch No 14	Upstream 1		2 (546–573)	1 (387)					7 (48–79)	5 (18–22)						
	Opuahou Stream Branch No 14	Upstream 2			1 (515)					41 (40–82)	1 (21)						
13	Kinloch Stream	Downstream 1		3 (408–892)				11 (44–81)								2 (74–84)	15 (40–67)
	Kinloch Stream	Upstream 1		1 (623)						10 (40–66)	28 (28–40)					64 (42–97)	10 (36–50)
	Kinloch Stream	Upstream 2		3 (399–594)						5 (55–60)	2 (32–33)			1 (131)		3 (53–64)	
14	Okuti River Branch No. 9	Downstream 1		2 (495–541)										13 (87–153)			
	Okuti River Branch No. 9	Upstream 1												1 (127)			

APPENDIX 2: BARRIER FISHING SITE PHOTOGRAPHS

Charlesworth Reserve Drain

Figure 6: Charlesworth Reserve Drain downstream view of culvert and flap gate externally (top left) and internally (top right). Upstream end of structure (bottom left) and upstream sampling reach (bottom right).

Rifle Range Waterway

Figure 7: Rifle Range Waterway, including the flap gate outlet (fixed in an open position; top) and the habitat immediately upstream (bottom).

Miln Drain

Figure 8: The upstream end of the structure in Miln Drain (top left), a large longfin eel caught upstream of the structure (top right), and the downstream (bottom left) and upstream (bottom right) sampling reaches.

Cass Bay Drain

Figure 9: The weir structure and steep fish ramp during the associated FPAT assessment (top left), the structure during the fish survey (note the addition of mussel spat rope; top right), the culvert downstream under Harbour View Tce which includes baffles increasing water depth (bottom left), and an example of the habitat in the Upstream 1 sampling reach.

Omaru Stream

Figure 10: The perched apron at the downstream end of the Omaru Stream culvert (top left), the upstream end of the culvert (top right), a pool typical of the reaches sampled downstream near the Rāpaki Marae (bottom left), and the Upstream 1 sampling reach.

Stream Reserve Drain

Figure 11: The perched apron at the downstream end of the culvert (top left), rocks imbedded through the culvert to enhance fish passage (top right), the Downstream 1 sampling reach, and one of the sampled pools upstream of the culvert (bottom right).

Church Lane Drain

Figure 12: The perched culvert in Church Lane Drain under Main Road (top left), a perched private culvert under a driveway downstream (top right), a natural barrier immediately downstream of the private culvert (bottom left), and the habitat sampled at site Upstream 1 (bottom right).

Raupō Stream

Figure 13: The perched culvert outlet (left) and the 6 m high vertical waterfall located 40 m downstream from the culvert (right). Note that this photograph only captures the entry to the waterfall, not the vertical face, as this could not be photographed safely.

Owhetoro Stream Branch No. 4

Figure 14: Owhetoro Stream Branch No. 4 culvert with perched apron (left) and the upstream sampling site (right).

Totara Stream

Figure 15: Totara Stream culvert with perched apron (top left), upstream view showing shallow water depth through the culvert (top right), downstream sampling site (bottom left), and upstream sampling site (bottom right).

Le Bons Bay Stream Branch No.13

Figure 16: The slightly perched culvert in Le Bons Bay Stream Branch No. 13 (top left), the downstream sampling reach (top right), the upstream sampling reach (top left), and a photo of some juvenile galaxias (bottom right), which were caught both upstream and downstream of the culvert.

Opuahou Stream Branch No. 14

Figure 17: Opuahou Stream Branch No. 14 downstream perched culvert under Puaha Road (top left), upstream perched culvert under SH75 (top right), and Downstream 1 (mid left), Upstream 1 (mid right), and Upstream 2 (bottom left) sampling reaches. Longfin eel caught at Upstream 1 site (bottom right).

Kinloch Stream

Figure 18: Culvert with perched apron in Kinloch Stream (top left), upstream ford with culvert (top right), and Downstream 1 (mid left), Upstream 1 (mid right), and Upstream 2 sampling sites (bottom left). Kōaro caught at Upstream 2 site (bottom right).

Okuti River Branch No. 9

Figure 19: Two weirs in Okuti River Branch No. 9 (top right), downstream sampling site (top right), upstream sampling site (bottom left) and a kōaro caught downstream (bottom right).

APPENDIX 3: HIGH PRIORITY STRUCTURES FOR OWNERSHIP REVIEW

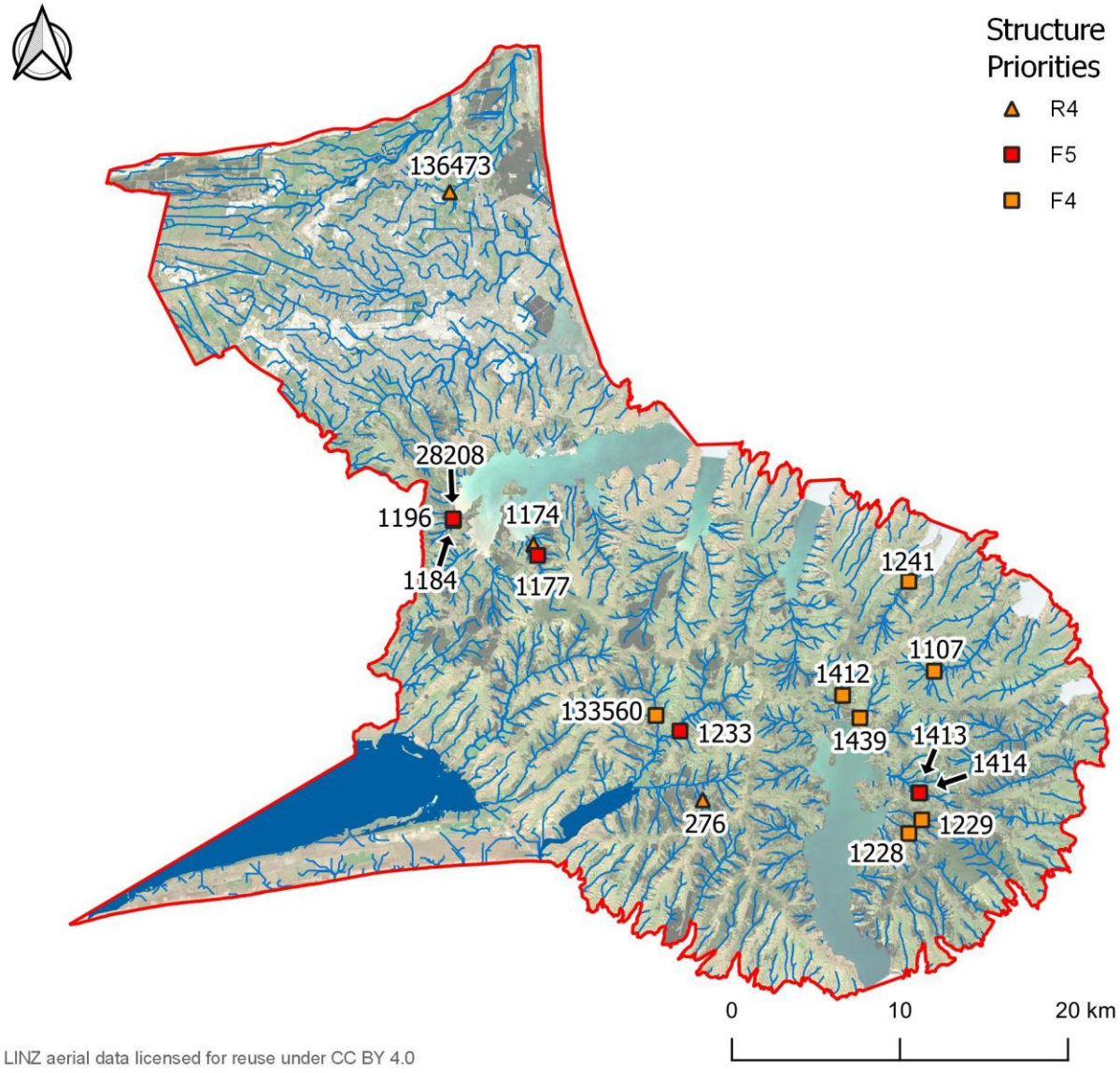

Figure 1: Location of high remediation and fishing priority structures that were not identified as CCC assets. Note that all these structures are of unknown ownership, except for structures with the FPAT ID's 136473 and 1233, which are under private and NZTA ownership, respectively.

Table 1: High remediation and fishing priority structures that were not identified as CCC assets. All structures are listed in the prioritisation database as being of unknown ownership, unless denoted otherwise.

Waterway	Catchment	FPAT ID	Structure Type	Easting	Northing	Priority Score
Okuti River Branch No 9	Okuti River	276	Weir	1586377	5150922	R4
Te Wharau Stream	Te Wharau Stream	1174	Ford with culvert	1576306	5166132	R4
Mundys Drain[1]	Styx River	136473	Culvert	1571322	5187116	R4
Te Wharau Stream	Te Wharau Stream	1177	Ford with culvert	1576552	5165478	F5
Opuahou Stream Branch No 17[2]	Opuahou Stream	1233	Culvert	1585022	5155029	F5
Takamatua Stream	Takamatua Stream	1413	Weir	1599237	5151349	F5
Takamatua Stream	Takamatua Stream	1414	Weir	1599286	5151337	F5
Bamfords Road Drain	Allandale	28208	Weir	1571520	5167657	F5
Opara Stream	Opara Stream	1107	Ford with culvert	1600148	5158584	F4
Bamfords Road Drain	Allandale	1184	Ford with culvert	1571534	5167559	F4
Bamfords Road Drain	Allandale	1196	Weir	1571532	5167612	F4
Balguerie Stream	Balguerie Stream	1228	Weir	1598641	5148926	F4
Grehan Stream	Grehan Stream	1229	Weir	1599409	5149736	F4
Little Akaloa Stream	Little Akaloa Bay	1241	Ford with culvert	1598640	5163935	F4
Pawsons Stream	Pawsons Stream	1412	Ford with culvert	1594698	5157143	F4
Pipers Stream	Pipers Stream	1439	Ford with culvert	1595728	5155802	F4
Hukahuka Turoa Stream Branch No 10	Hukahuka Turoa Stream	133560	Ford with culvert	1583594	5155952	F4

Note: [1]Private ownership. [2]NZTA ownership.