



Figure 4: Watercare Services Ltd water gauging flume located on the Nihotupu Stream, approximately 200 m upstream of the Upper Nihotupu Reservoir.



Figure 5: Obsolete water flow-gauging weir located on the Waitakere River above the Waitakere falls, but below the dam.

4.2 Other Waitakere Ranges Regional Park Sites

Twenty four structures were located within the Waitakere Ranges Regional Park outside the water supply catchments (Nihotupu, Huia and Waitakere). The majority were culverts located either under public roads in the south of the Park or on small streams in the Waitakere Golf Course.

Structures assessed as fish passage barriers affected 5 kilometres of stream reach amongst 220 hectares of parkland.

4.3 Muriwai Regional Park

One structure was evaluated; a ford located on the Okiritoto Stream. The ford consists of five 0.6 m diameter culverts in parallel and provides access to forestry operations beyond the Okiritoto Stream (Figure 6).

The structure was assessed as a barrier to fish passage under most flow conditions despite an ARC fish survey in 1998 capturing non-climbing species (redfinned bully, inanga and common smelt) above the structure. During the present survey several culvert outlets were perched and water velocity through all barrels exceeded 1.5 metres per second, well in excess of the recommended $0.3 \text{ m}^3 \cdot \text{s}^{-1}$ (ARC 2000).



Figure 6: Five barrel ford located on the Okiritoto Stream within the Muriwai Regional Park

Although Muriwai is considerably smaller than the Waitakere Ranges Regional Park in size, a large percentage of catchment outside the park (1635 ha, 95%) and length of the Okiritoto Stream and its tributaries (33.0 km) were affected (Table 5).

Table 5: Comparison of catchment area and stream length lost upstream of in-stream structures assessed as barriers to fish passage under most flow conditions within the Muriwai Regional Park (ha, hectare; km, kilometre).

Catchment	Total catchment area (ha)	Catchment area lost (ha)	Percentage catchment area lost	Stream length lost (km)
Muriwai	1720	1635	95	33.0

5 Discussion

The Waitakere Ranges contains one of the largest remnant of indigenous forest in the Auckland Region with numerous high quality rocky bottom waterways with abundant fish habitat. These rivers and streams support a diverse indigenous fishery including koaro, banded kokopu, shortjaw kokopu, inanga, longfinned and shortfinned eel, common bully, Crans bully, redfinned bully, and common smelt.

Most indigenous fish recorded from the Waitakere Ranges and Muriwai regional parks, with the exception of Crans bully, are diadromous requiring access to the sea to complete their lifecycle, though in some cases the marine phase can be substituted by an extended period in lakes or reservoirs (i.e. lake-locked populations of banded kokopu and koaro may have established within the Nihotupu Huia and Waitakere reservoir's).

Several species of Galaxiids and both longfinned and shortfinned eels are known for their ability to climb obstacles to varying degrees. Koaro are particularly adept and have been observed negotiating near vertical dam faces. Koaro and shortjaw kokopu have specialised habitat requirements generally limited in Auckland to the forested areas of the Waitakere and Hunua Ranges.

The number of catchments affected by in-stream barriers to fish passage, particularly within the water supply catchments, is high. These barriers are likely to be adversely affecting the abundance, distribution and diversity of indigenous fish within the study areas, either through severance of upstream habitat or via restricted recruitment. This is supported by reviewing data from the Fish Database, which shows a marked difference in fish communities above, below and between dams. For example, the fish communities of streams in the upper Nihotupu, Huia and Waitakere catchments appear depauperate with only longfinned eel and banded kokopu recorded. Fish diversity improves in catchments of the lower reservoirs with bullies and koaro recorded. This is of particular concern given the limited areas of high quality fish habitat remaining in the Auckland Region, and that one important function of the Regional Park network is to protect native flora and fauna and their habitats.

The high diversity of indigenous fish in the Waitakere Ranges unaffected by the water supply reservoirs is evident in Karamatura and Opanuku streams. In 2001, shortjaw kokopu were recorded in both streams by Massey University (Joy and Death 2003), the first positive identification of this species for Waitakere Ranges.

The use of culverts and fords is common in New Zealand, particularly as a cost effective means for roads to cross rivers and streams. Inappropriate design, construction and/or maintenance can quickly result in these structures adversely affecting aquatic life. Traditionally, culverts have been installed with consideration of their hydraulic capacity only, and little thought given to the need for fish passage (Boubee et al. 1993). Recent

recognition of the importance of ensuring fish passage and structure design innovations have improved the situation, though this has yet to filter through in a substantive way to the retrofitting of existing structures.



Figure 6: Perched culvert on the Island Stream below the Nihotupu Dam Road. Note both culvert outlet and apron are perched.

The ARC has developed guidelines on fish passage, which identify parameters important for ensuring fish passage and are highly relevant in this study (ARC 2000). The ARC fish passage guidelines identify height (vertical differential between streambed and structure outlet), water velocity and turbulence, water depth, channel length, light, and climbing medium as important measures. Most of the culverts assessed in this study were perched, undersized and badly positioned promoting erosion of bed material at the culvert outfall.

The results of the present study is consistent with those found during a survey of the Hunua Ranges and Waharua regional parks completed in June 2004 (Barnes, 2004). Incorrectly installed and maintained culverts formed the bulk of fish passage barriers identified, typically located on access roads to water supply infrastructure. A programme of works to restore fish passage to high priority catchments is proposed.

Speirs and Kelly (2001) encountered a similar proportion of in-stream barriers in streams of the Coromandel Peninsula and suggested that this reflected in part the steep nature of the geology and frequent high intensive rainfall events, which move large amounts of

bed material and frequently scour stream channels. Similar geologic and meteorologic conditions are likely in the Waitakere Ranges where most barriers identified were culverts located under roads traversing steep catchments (>25°) with friable soils and where downstream erosion protection was consistently absent. An apparent lack of regular maintenance was a possible exacerbating factor.

5.1 Legislative Obligations

The provision of fish passage for in-stream structures has been a legal requirement in New Zealand since 1983, following the enactment of the Freshwater Fisheries Regulations by the New Zealand Parliament. Furthermore, the RMA in 1991 added additional requirements ensuring the sustainable management of natural and physical resources.

The ARC administers several statutory documents under the RMA or antecedent legislation, which establish rules pertaining to activities within watercourses. These include the Transitional Regional Plan, the Regional Policy Statement and the Proposed Auckland Regional Plan - Air, Land, Water (ALWP).

The ALWP contains numerous references to the importance of fish passage in maintaining and enhancing the freshwater environment and maintaining the cultural values of tangata whenua. Specifically, a rule in the proposed plan permits the continued occupation of existing in-stream structures provided that certain conditions, including provision of fish passage, are complied with. Non-complying structures require consent for a discretionary activity.

Despite the protection of legislation and regulation it is apparent from this study and others conducted nationwide that protective measures ensuring fish passage may be inconsistently or ineffectively applied (Evans and Glover 1999; Joy and Death 2001; Speirs and Kelly 2001; Taranaki Regional Council 2001; and Taylor 2001).

5.2 Prioritisation of Fish Passage Restoration

There is clearly a lot of work required to restore fish passage to a significant number of rivers and streams of the Waitakere Ranges and Muriwai regional parks. Logically, restorative work requires prioritisation to ensure structures impacting large areas of the highest quality fish habitat are fixed first.

Prioritisation should follow criteria established by the ARC fish passage guidelines (ARC 2000) , which state:

When considering the need to facilitate fish passage, it is essential that the following points are considered;

- *species present and distribution within the catchment,*
- *the size and type of habitat available up stream,*
- *the presence of other migration barriers both upstream and downstream of the culvert,*
- *the timing of fish migrations, duration and their flow requirements, and*
- *elevation and distance from the sea.*

The highest priority for fish passage restoration are the barriers located on streams within the Huia and Nihotupu catchments with substantial upstream native fish habitat. The Nihotupu gauging flume warrants immediate attention because the large area of catchment affected upstream. Similarly, the structures located at the base of the Waitakere Reservoir and the obsolete gauging weir on Island Stream should be removed.

Retro-fitting to restore fish passage or removal of barriers within the water supply catchment also supports mitigation proposed by Watercare Services Ltd to offset the adverse effects of the five water reservoirs on native fish. The benefits of a native fish transfer programme potentially diminishes if existing barriers upstream of the reservoirs remain.

The single barrier within the Muriwai Regional Park could be fixed relatively easily and would restore fish passage to the lower and middle reaches of the Okiritoto Stream. Modification to the structure to reduce barrel velocities and the repair of outlet conditions is recommended.

Where restoration of fish passage is not practicable, then consent may be required to permit the continued occupation of fish barriers within waterways of the Waitakere Ranges and Muriwai regional parks.

6 Conclusion

A high proportion of New Zealand's indigenous fish fauna are diadromous requiring connection between high quality adult riverine habitat and marine or lake environments. Incorrectly installed or maintained in-stream structures such as culverts, fords, dams or weirs can prevent or restrict upstream migration of fish.

Substantial areas of the Waitakere Ranges and Muriwai regional parks are affected by in-stream barriers to fish passage, particularly below the five water supply reservoirs. These structures prevent fish access to significant lengths of high quality streams, potentially affecting fish diversity and abundance.

In many cases restoration of fish passage would be relatively straight forward and of low cost. The ARC provides a technical guideline to assist in this regard.

References

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Appendix 1: In-Stream Structure Record Sheet

ID:	Number	Observer:	Text
Date:	Number	Co-ordinates:	Easting: Number Northing: <i>Number</i>
Location:	Text	Inland distance (km):	Text
Owner:	Public/Utility/Private	River system:	Text
Altitude (m):	Number	Stream name:	Text
Catchment area (ha):	Number	Catchment No:	Number

At Barrier:

Upstream:	Dominant catchment landcover: <i>Text</i> Dominant riparian cover: <i>Text</i>	
Downstream:	Dominant catchment landcover: <i>Text</i> Dominant riparian cover: <i>Text</i>	
Dominant substrate type: Upstream:	Type	%
	Type	%
	Type	%
Downstream:	Type	%
	Type	%
	ype	
Barriers: Upstream:	Yes/No	
Downstream:	Yes/No	
Tidal:	Yes/No	

Structure Description

Type of Structure:		Culvert/Ford/Weir/Other	
Weir:	V-notch: <i>Yes/No</i>	Height (m): <i>Number</i>	
Ford :	No. culverts:	Number	
Culvert:			
Diameter (m):	Number		
Height (m):	Number	Width (m):	Number
Comment:	Text		
Materials:		Smooth metal/Corrugated/Smooth concrete/Rough concrete	
Length (m):	Number		
Substrate within structure:	Yes/No	Type	%
		Type	%
		Type	%
Substrate depth (m):	Number		
Observed water flow (m/s):	Number		
Flow conditions:	Normal/Low/High		

Outlet Conditions (downstream)

Water level control at outlet:	Uniform/Perched/Ponded If ponded: WL (m): <i>Number</i> If perched: WL (m): <i>Number</i> BL (m): <i>Number</i>
Outlet type:	Projecting/Flush with Headwall/Bevelled & flush
Apron present:	Yes/No
	Length (m): <i>Number</i> Slope (°): <i>Number</i> <i>Number</i>

Inlet Conditions (upstream)

Water level control at outlet:	Uniform/Perched/Ponded If ponded: WL (m): <i>Number</i> If perched: WL (m): <i>Number</i> BL (m): <i>Number</i>
Inlet type:	Projecting/Flush with Headwall/Bevelled & flush
Apron present:	Yes/No
	Length (m): <i>Number</i> Slope (°): <i>Number</i> Drop (m): <i>Number</i>

Structure attributes

Bed level:	Above/Same/Below
Structure width:	Narrower/Same/Wider
Structure gradient:	Flatter/Same/Steeper
Structure alignment:	Straight; straight/Straight; curved/Curved; straight/Curve;curve

Bank Protection

Upstream TR:	Yes/No	Type:	Rip rap/armour/other
		Erosion:	Yes/No
Upstream TL:	Yes/No	Type:	Rip rap/armour/other
		Erosion:	Yes/No
Upstream above:		Erosion:	Yes/No
Downstream TR:	Yes/No	Type:	Rip rap/armour/other
		Erosion:	Yes/No
Downstream TL:	Yes/No	Type:	Rip rap/armour/other
		Erosion:	Yes/No
Downstream above:		Erosion:	Yes/No

Streambed Protection

Upstream:	Yes/No
	Type: Rip rap/armour/other
Downstream:	Yes/No
	Type: Rip rap/armour/other

Culvert Barrel

Blockages:	Yes/No
Blockage type:	Inlet/outlet/barrel
Any breaks in culvert:	Yes/No

Baffles etc

Baffles:	Yes/No
Spoilers:	Yes/No

Comments

Text

Severity of Fish Passage Restriction

None/low flow/most flow/high flow