FLOW REQUIREMENTS FOR FISH PASSAGE AND INSTREAM HABITAT DOWNSTREAM OF THE WAIAUA HYDROELECTRIC POWER SCHEME WEIR

Prepared for the Taranaki Regional Council

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Waiaua Hydroelectric Power Scheme - fish habitat and passage downstream of weir

Introduction

The Waiaua Power Scheme diverts water from the Waiaua River and discharges it directly into an ocean outfall at the Opunake Beach. A 4.5 m weir controls water levels for the diversion and releases a minimum flow for the operation of a fishpass and to enable fish passage below the weir. The purpose of this report is to estimate the flows required for instream habitat and native fish passage in the critical reaches of the Waiaua River below the weir and to make an estimate of the quality of the habitat which would be provided by different levels of flow.

Method

Four cross-sections were surveyed within a 105m section of the Waiaua River just below the weir. Judging from photographs and hydraulic analysis, two of these represented average river habitat and the other two were sections considered to be critical for fish passage.

The variation of water level with discharge was estimated at each cross-section from the hydraulic properties and Manning's equation. This method is known as the MANSQ procedure in IFIM manuals. Experience with this method has shown that manning's N varies with discharge at sites other than critical hydraulic controls. Typical values were assumed for the variation of Manning's N with discharge at the sections. Where the control was near critical, no variation was assumed, but where the flow was not critical Manning's N was assumed to vary with discharge to the power of up to -0.4. The actual values selected depended on the cross section and the degree to which the flow approached critical flow.

Flows of between 0.01 m^3/s and 0.15 m^3/s were simulated and water levels and velocity distributions predicted.

Once water levels were estimated at each site for the simulated flows, average water depths and velocities, maximum depths, and weighted usable area for food-producing habitat, adult brown trout habitat, and native fish habitat were estimated. Maximum velocities were not calculated because in boulder rivers maximum velocity is a result of local acceleration around boulders and there is no way of predicting this.

Results

Fish passage

The average flow in the 4 cross sections was 0.38 m^3/s. At this flow, the maximum depths of flowing water in the four cross-sections surveyed were 0.11, 0.14, 0.33, and 0.13 m in sections 1 to 4 respectively. The usual minimum passage depth for adult trout passage is 0.15 m over a weir. Native fish are commonly found in water depths of less than 0.1 m, and of the more common riverine species, only torrentfish and bluegilled bullies are commonly found in

deeper water. Passage depths for native fish have not been established, but some fish species require only a moist surface for upstream passage. In my opinion, an average depth of 0.05 m provides suitable habitat for many common species and would be adequate for native fish passage.

Cross-sections 1 and 4 were the most critical for passage with maximum depths of 0.08 m at flows of 10 l/s and higher average velocities than at the other two sections. A flow of 60 l/s in the Waiaua River below the weir provides an average depth of 0.05 m at the most critical section (section 1) and close to this depth at two other sections (Table 1). At this flow, the average velocity ranged from 0.04 m/s in the slower areas to 0.27 m/s in the shallowest section and would not be a barrier to the passage of any native species and would provide suitable invertebrate habitat in the riffle areas. Minimum passage depths for adult trout (i.e. 0.15 m) are provided by a flow of 120 l/s at section 1 (Table 1).

Instream habitat

The variation of native fish habitat with flow was calculated for the more common riverine species, most of which are present in the Waiaua River. Native fish can be grouped as either edge-dwelling (*Galaxias vulgaris* and upland bully), fast-water (torrentfish and bluegilled bully), or intermediate (redfinned bully and common bully). Flow-habitat relationships for these three groups show that decreasing flows favours the preferred habitat of edge-dwelling species, whereas increasing flows favours the fast-water species. Flow requirements for the intermediate group provides a compromise between the opposing requirements of the other two groups and often shows clearly defined optima and points of inflection that are not evident in the habitat flow relationships for the other two groups. this pattern was evident in the Waiaua River, with torrentfish and bluegilled bully habitat increasing with discharge and *Galaxias vulgaris* and upland bully habitat decreasing with discharge. Both redfinned and common bully habitat both showed optimum habitat values at about 100 l/s and declines in habitat at flows of less than 60 l/s (Fig. 1).

A flow of 180 l/s would provide 15% food producing habitat (Table 2) equivalent to that in the Kapoaiaia, Kapuni, Manganui, and Waingongoro Rivers at their low flows, but better than that in the Mangaoraka and Waiongana Streams at their low flows.

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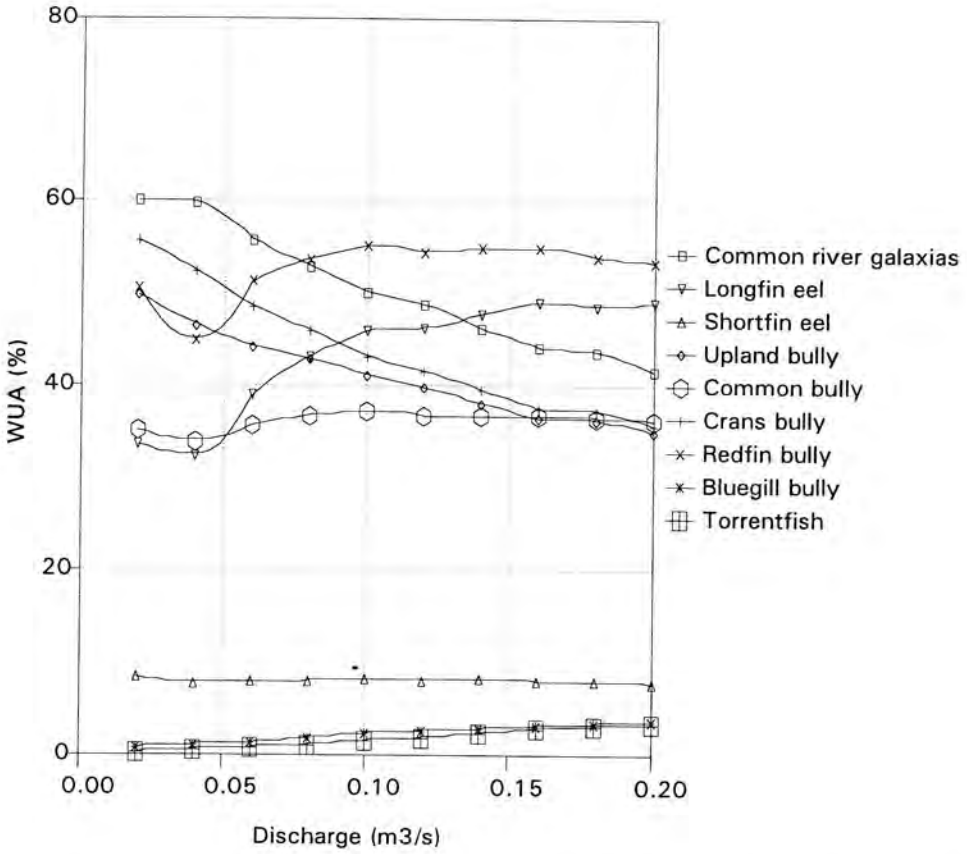


Figure 1 Variation of native fish habitat with flow in the Waiaua River below the weir.

Habitat quality

Native fish habitat begins to decline at flows less than 60 l/s and is at an optimum for redfinned bullies and common bullies at a flow of 100 l/s (Table 2, Fig. 1). With flows at or less than 60 l/s, the quality of the food producing habitat below the weir is poor. As the flow increases, the quality increases until at 180 l/s, it matches the quality of the Kapoaiaia, Kapuni, Manganui, and Waingongoro Rivers at their low flows.

Summary

Flow requirements vary depending upon the use that is expected of the river. In the Waiaua River, flow requirements varied from 60 to 180 l/s depending upon the use and standards of assessment.

- Adequate native fish passage and minimum native fish habitat would be provided by a flow of 60 l/s.
- Optimum habitat for redfinned bullies and common bullies is provided by a flow of 100 l/s.
- Adequate passage depth for brown trout is provided by a flow of 120 l/s.
- Minimum (15%) food producing habitat is provided by a flow of 180 l/s.

I would recommend that a minimum flow of 100 l/s would provide for native fish passage and habitat in this section of the river and would probably provide sufficient depth of passage for trout. This recommendation would be consistent with other native fish flow recommendations I have made in the Waipara and Kakanui Rivers, both South Island east coast rivers. The quality of the food producing habitat, although poorer than many Taranaki Rivers, is probably appropriate for a small stream. A lower minimum flow of 60 l/s would provide for minimum native fish requirements and a higher minimum flow of 180 l/s would provide food producing habitat consistent with a 15% minimum guideline.

Table 1 **WAIAUA RIVER BELOW WEIR - Cross-section Summary**

Section 1 Hydraulic Parameters

Flow (m3/s)	Length (m)	Area (m2)	Width (m)	Wetted perimeter (m)	Mean depth (m)	Mean velocity (m/s)	Maximum depth (m)
.20	19.3	.39	4.85	5.64	.08	.38	.17
.18	19.3	.36	4.85	5.58	.07	.37	.16
.16	19.3	.33	4.45	5.52	.07	.36	.16
.14	19.3	.30	4.45	5.41	.07	.34	.15
.12	19.3	.27	4.45	5.30	.06	.32	.15
.10	19.3	.24	3.55	4.90	.07	.33	.14
.08	19.3	.20	3.55	4.61	.06	.30	.13
.06	19.3	.16	3.55	4.26	.05	.27	.12
.04	19.3	.12	3.55	3.85	.03	.22	.11
.02	19.3	.07	2.20	3.07	.03	.19	.10

Section 2 Hydraulic Parameters

Flow (m3/s)	Length (m)	Area (m2)	Width (m)	Wetted perimeter (m)	Mean depth (m)	Mean velocity (m/s)	Maximum depth (m)
.20	17.9	.55	5.55	7.25	.10	.33	.20
.18	17.9	.52	5.55	7.15	.09	.31	.19
.16	17.9	.49	5.15	7.02	.10	.28	.19
.14	17.9	.45	5.15	6.87	.09	.26	.18
.12	17.9	.42	5.15	6.70	.08	.24	.18
.10	17.9	.38	5.15	6.52	.07	.22	.17
.08	17.9	.33	5.15	6.31	.06	.19	.16
.06	17.9	.28	5.15	6.06	.05	.16	.15
.04	17.9	.22	4.75	5.48	.05	.13	.14
.02	17.9	.14	2.10	4.15	.07	.05	.12

Section 3 Hydraulic Parameters

Flow (m3/s)	Length (m)	Area (m2)	Width (m)	Wetted perimeter (m)	Mean depth (m)	Mean velocity (m/s)	Maximum depth (m)
.20	18.8	1.68	4.90	7.51	.34	.09	.50
.18	18.8	1.61	4.90	7.40	.33	.08	.48
.16	18.8	1.53	4.90	7.29	.31	.08	.47
.14	18.8	1.44	4.90	7.17	.29	.07	.46
.12	18.8	1.35	4.90	7.03	.28	.06	.44
.10	18.8	1.25	4.60	6.84	.27	.06	.42
.08	18.8	1.13	4.60	6.57	.25	.05	.40
.06	18.8	.99	4.60	6.25	.22	.04	.37
.04	18.8	.82	4.60	5.83	.18	.03	.33
.02	18.8	.61	2.90	4.70	.21	.03	.28

Section 4 Hydraulic Parameters

Flow (m3/s)	Length (m)	Area (m2)	Width (m)	Wetted perimeter (m)	Mean depth (m)	Mean velocity (m/s)	Maximum depth (m)
.20	20.9	.76	6.10	7.22	.12	.31	.21
.18	20.9	.71	6.10	7.16	.12	.29	.20
.16	20.9	.66	5.80	7.07	.11	.29	.20
.14	20.9	.61	5.80	6.97	.11	.27	.19
.12	20.9	.56	5.80	6.86	.10	.25	.18
.10	20.9	.50	5.80	6.74	.09	.23	.17
.08	20.9	.43	5.80	6.61	.07	.21	.16
.06	20.9	.36	5.35	6.39	.07	.18	.15
.04	20.9	.27	5.35	5.94	.05	.15	.13
.02	20.9	.17	3.10	4.47	.05	.09	.11

Table 2 **WAIAUA RIVER BELOW WEIR - Reach Summary**

Hydraulic Parameters for 76.92m of reach

	Flow (m3/s)	Area (m2)	Width (m)	Wetted perimeter (m)	Depth Mean (m)	Depth Maximum (m)	Mean Velocity (m/s)	Habitat Percentage Pool	Run	Riffle
1	.20	.84	5.37	6.90	.16	.50	.278	48.8	27.8	23.4
2	.18	.80	5.37	6.82	.15	.48	.264	49.9	26.7	23.4
3	.16	.75	5.09	6.72	.15	.47	.255	55.0	21.5	23.5
4	.14	.70	5.09	6.60	.14	.46	.238	57.8	20.0	22.2
5	.12	.65	5.09	6.47	.13	.44	.220	58.4	19.4	22.2
6	.10	.59	4.79	6.25	.12	.42	.211	59.7	17.2	23.0
7	.08	.52	4.79	6.03	.11	.40	.189	59.7	18.2	22.1
8	.06	.45	4.67	5.74	.10	.37	.164	61.1	17.7	21.2
9	.04	.36	4.58	5.28	.08	.33	.135	58.5	18.9	22.6
10	.02	.24	2.59	4.10	.09	.28	.090	69.7	16.6	13.7

Substrate for 76.92m of reach

	Flow (m3/s)	Boulder	Cobble	Gravel	Fine gravel	Sand
1	.20	72.6	18.7	6.1	1.1	1.4
2	.18	72.6	18.7	6.1	1.1	1.4
3	.16	72.4	18.6	6.3	1.1	1.4
4	.14	72.4	18.6	6.3	1.1	1.4
5	.12	72.4	18.6	6.3	1.1	1.4
6	.10	69.6	20.1	7.3	1.4	1.5
7	.08	69.6	20.1	7.3	1.4	1.5
8	.06	69.3	20.3	7.4	1.4	1.5
9	.04	69.0	20.5	7.4	1.4	1.5
10	.02	64.7	23.5	8.5	1.9	1.4

Potential Habitat (WUA) for 76.92m of reach

Weighting factors used are: Depth, Velocity and Substrate

Suitability weighting function	Flow (m3/s)	WUA (m)	WUA (%)
"COMMON RIVER GALAXIAS"	.20	2.24	41.7
	.18	2.34	43.6
	.16	2.25	44.2
	.14	2.36	46.3
	.12	2.48	48.8
	.10	2.40	50.1
	.08	2.54	53.0
	.06	2.61	55.9
	.04	2.73	59.8
	.02	1.56	60.2
"LONGFIN EEL"	.20	2.63	49.0
	.18	2.61	48.6
	.16	2.50	49.0
	.14	2.43	47.8
	.12	2.36	46.4
	.10	2.20	46.0
	.08	2.07	43.2
	.06	1.83	39.1
	.04	1.48	32.4
	.02	.87	33.5
"SHORTFIN EEL"	.20	.42	7.8
	.18	.42	7.9
	.16	.41	8.1
	.14	.41	8.1
	.12	.41	8.0
	.10	.39	8.2
	.08	.39	8.1
	.06	.37	8.0
	.04	.35	7.7
	.02	.22	8.5
"UPLAND BULLY"	.20	1.87	34.9
	.18	1.95	36.3
	.16	1.86	36.5
	.14	1.94	38.1
	.12	2.02	39.8
	.10	1.97	41.1
	.08	2.05	42.9
	.06	2.07	44.3
	.04	2.12	46.4
	.02	1.29	49.9

Weighting factors used are: Depth, Velocity and Substrate

Suitability weighting function	Flow (m3/s)	WUA (m)	WUA (%)
"COMMON BULLY"	.20	1.94	36.2
	.18	1.96	36.5
	.16	1.86	36.6
	.14	1.87	36.8
	.12	1.87	36.8
	.10	1.79	37.3
	.08	1.76	36.8
	.06	1.67	35.8
	.04	1.55	34.0
	.02	.91	35.1
"CRANS BULLY"	.20	1.92	35.7
	.18	2.00	37.3
	.16	1.91	37.4
	.14	2.01	39.4
	.12	2.12	41.7
	.10	2.07	43.1
	.08	2.20	45.9
	.06	2.27	48.5
	.04	2.40	52.5
	.02	1.45	55.8
"REDFIN BULLY"	.20	2.87	53.4
	.18	2.89	53.9
	.16	2.80	55.0
	.14	2.79	54.9
	.12	2.77	54.5
	.10	2.65	55.2
	.08	2.58	53.8
	.06	2.39	51.3
	.04	2.06	45.1
	.02	1.31	50.6
"BLUEGILL BULLY"	.20	.19	3.5
	.18	.17	3.2
	.16	.16	3.1
	.14	.14	2.8
	.12	.13	2.5
	.10	.11	2.2
	.08	.09	1.8
	.06	.06	1.4
	.04	.04	.9
	.02	.02	.8

Weighting factors used are: Depth, Velocity and Substrate

Suitability weighting function	Flow (m3/s)	WUA (m)	WUA (%)
"TORRENTFISH"	.20	.19	3.4
	.18	.16	3.0
	.16	.14	2.7
	.14	.12	2.3
	.12	.09	1.9
	.10	.07	1.5
	.08	.05	1.1
	.06	.04	.8
	.04	.02	.5
	.02	.01	.4
Food producing (Waters)	.20	.91	17.0
	.18	.81	15.0
	.16	.69	13.6
	.14	.58	11.5
	.12	.46	9.0
	.10	.33	6.9
	.08	.25	5.2
	.06	.18	3.8
	.04	.12	2.7
	.02	.04	1.4

Waiaua River
Cross-section 1

Across

(TSB56/1)

Upstream

(TSB56/2)

Downstream

(TSB56/3)

Waiaua River
Cross-section 2

Across

(TSB56/5)

Upstream

(TSB56/6)

Downstream

(TSB56/7)

Waiaua River
Cross-section 3

Across

(TSB56/9)

Upstream

(TSB56/8)

Downstream

(TSB56/10)

Waiaua River
Cross-section 4

Across

(TSB56/12)

Upstream

(TSB56/11)

Downstream

(TSB56/13)

General view of Waiaua River flow passage surveyed reach downstream of the Opunake weir

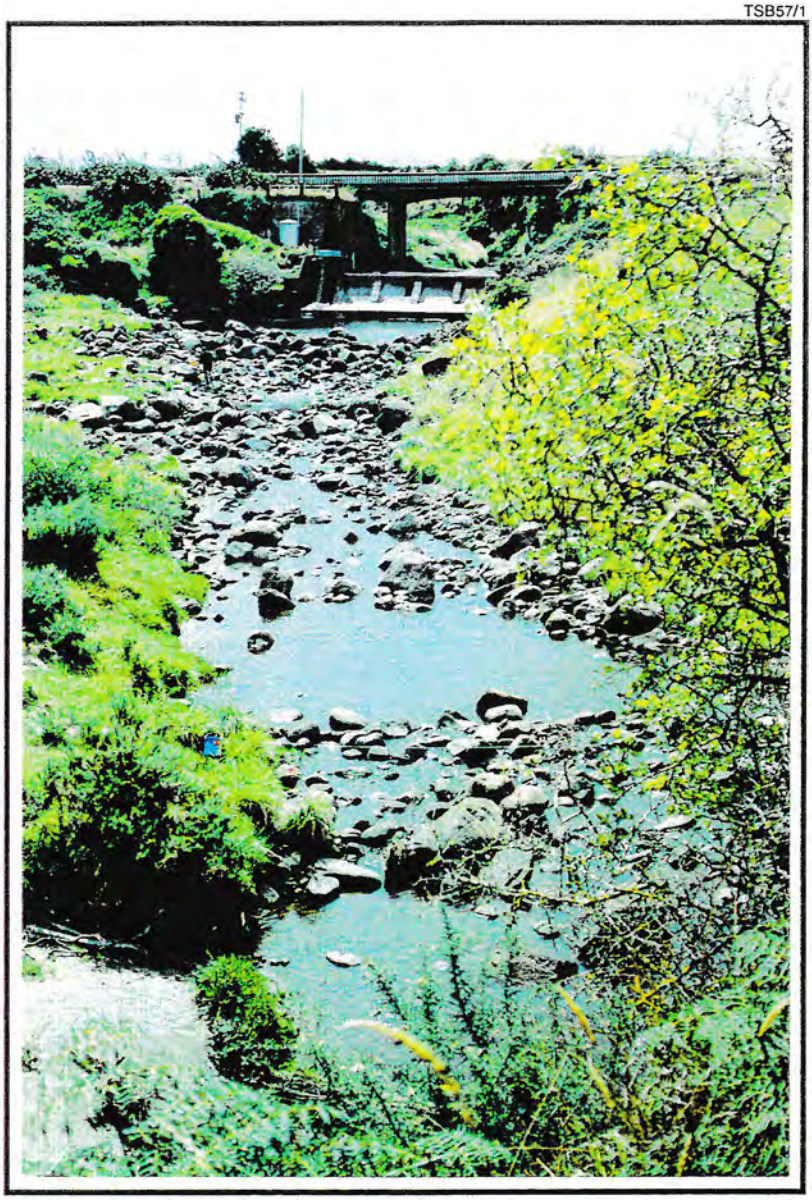
(TSB57/4)

(TSB57/2)

(TSB57/3)

TSB57/1

General view of surveyed reach (looking upstream) with cross-section 4 in foreground



Gabion basket weir downstream of fish pass (flow. **3** 1 L/sec) showing constriction of flow (upstream of cross-section 1)

TSB56/4