RESOURCE MANAGEMENT GROUP

HAWKE'S BAY REGIONAL COUNCIL

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Lower Ngaruroro River Instream Flow Assessment

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SAFEGUARDING YOUR ENVIRONMENT + KAITIAKI TUKU IHO

Environmental Management Group
Technical Report

Hydrology Section

Lower Ngaruroro River Instream Flow Assessment

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EXECUTIVE SUMMARY

The increasing pressure on the water resources in the Ngaruroro catchment has necessitated the implementation of this research to provide scientifically robust and peer-reviewed data for setting minimum flows for this catchment. Minimum flows are a vital component of water management in the Hawke's Bay Regional Council Regional Resource Management Plan. This report provides scientific data to inform the process of setting the minimum flow of the lower Ngaruroro River.

Field work began in the summer of 2009/2010 and data collected were input into the software package Rhyhabim (River Hydraulics and Habitat Simulation) for analysis. Habitat suitability criteria (HSC) for species present in the lower Ngaruroro catchment were used to calculate the quantity of habitat over a range of flows.

Those species with the highest flow requirements were identified as critical species and their habitat assessed against the mean annual low flow (MALF).

The flows required to retain 90% of habitat at the MALF for rainbow trout and torrentfish (most flow demanding sport and native fish) are:

- 3900 l/s for rainbow trout
- 4200 l/s for torrentfish

Allocation limits (in conjunction with minimum flows) are a vital component of water management regimes. These limits define the total amount of abstraction that can occur above the minimum flow and limit the impact of water abstraction on flow variability, including the frequency of occurrence and duration of the minimum flow. Allocation limits for the Ngaruroro catchment will be addressed in subsequent HBRC publications, presenting various allocation scenarios and their respective impact on the flow regime.

There are many considerations to be made in the water management process, the most important of which is defining the values that the community wishes to maintain or enhance. It is not the intention of this report to define those values as that process involves all stakeholders in the Ngaruroro catchment as part of a full assessment of RMA Section II, which addresses economic, cultural, social, and environmental matters. However, there are many National and Regional examples to guide minimum flow selection for instream habitat, which have been incorporated in this report.

EXECUTIVE SUMMARY I

1.0 INTRODUCTION 1
1.2 Purpose 1
1.3 Instream Habitat Modelling 1
1.4 History of Ngaruroro Minimum Flow Investigations 1

2.0 NGARURORO HYDROLOGY 2
2.1 Catchment Characteristics 2
2.2 Naturalised Flows 3

3.0 REACH SELECTION AND HABITAT MODELLING METHODOLOGY 4
3.1 Stakeholder Consultation 4
3.2 Reach Selection 4
3.3 Habitat Mapping 6
3.4 Data Collection 12
3.5 Data Checking 12
3.6 Ratings 12
3.7 Habitat Predictions 13
3.7.1 Suitability Criteria 13
3.7.2 Modelled Flow Range 14

4.0 RESULTS 14
4.1 Trout Habitat 15
4.2 Native Fish Habitat 17

5.0 DISCUSSION 19
5.1 Ecological Relevance of the MALF 19
5.2 Reconciling Flow Requirements of Multiple Instream Values 20
5.3 Minimum Flow Setting Process 21
5.4 Allocation Limits 22

6.0 CONCLUSIONS 23

REFERENCES 24

APPENDIX A: NGARURORO AERIAL PHOTOMOSAICS 26

APPENDIX B: HABITAT SUITABILITY CRITERIA 28

LIST OF FIGURES

Figure 1: The Ngaruroro catchment and 2009/2010 instream habitat modelling study reach.....3
Figure 2: Stream gradient for the Ngaruroro River. Study area indicated by red square.....5
Figure 3: River reach selected for instream habitat modelling of the lower Ngaruroro River outlined in red. State Highway 2 bridge is located at the downstream end of the study reach.....6
Figure 4: Example of a swift run flow type.....8
Figure 5: Example of an open run flow type.....9
Figure 6: Example of an overhang run flow type.....10
Figure 7: Example of a backwater.....11
Figure 8: Ratings of all transects in the Ngaruroro River Rhyhabsim model (log-log scale).....13
Figure 9: Rainbow and brown trout habitat WUA responses.....16
Figure 10: Longfin and shortfin eel habitat WUA responses.....17
Figure 11: Habitat WUA responses for bluegill bully, koaro, smelt, and torrentfish.....18
Figure 12: Habitat WUA responses for common bully, crans bully, dwarf galaxias, lamprey, and redfin bully.....19
Figure 13: Schematic showing an idealised water allocation regime. From Harkness (2010[2]).....22

LIST OF TABLES

Table 1: Naturalised flow statistics (l/s) for the Ngaruroro River at Fernhill. Exceedence statistics based on November-April period.....4
Table 2: Habitat mapping data for the lower Ngaruroro River.....6
Table 3: Fish species in the Ngaruroro catchment. Bold type indicates species with 'At Risk – Declining' threat classifications as per Allibone et al 2010.....13
Table 4: Flows providing a range of habitat WUA retention levels for species modelled in the Ngaruroro River. Potential management species indicated in bold. HSC are from Jowett and Richardson (2008) unless otherwise noted.....15
Table 5: Suggested significance ranking and levels of habitat retention of critical species values. From Jowett and Hayes 2004.....20
Table 6: Percent difference between mean annual low flows and minimum flow levels for major catchments in Hawke's Bay.....21
Table 7: Flows required to retain 90% of habitat available at the MALF for rainbow trout and torrentfish.....23

1.0 INTRODUCTION

1.2 Purpose

The Ngaruroro River is highly valued for irrigation, recreation, amenity, and cultural significance to Maori. Balancing these values calls for the most up-to-date scientific research and continued review of management strategies. This investigation has been completed in response to increasing irrigation demand and necessity for scientifically supported, transparent, and robust water management rules. The results of the model will inform the process of setting a minimum flow which balances the needs of instream and out of stream users.

1.3 Instream Habitat Modelling

River management in New Zealand and overseas often focuses on a balance of water needs for maintaining instream ecology while providing for out-of-stream water use. One-dimensional hydraulic habitat models like River Hydraulics and Habitat Simulation, or Rhyhabsim (Jowett 2004), allow water managers to identify the relationship between instream habitat and river flow which can be used to evaluate various management regimes.

Rhyhabsim uses the combination of a hydraulic simulation model to predict flow conditions (depth, velocity) and biological models that show how predicted flow conditions change the amount of available habitat for a range of species. The available habitat predictions are presented by an index called Weighted Usable Area (WUA), which if often expressed as an area per length of river, or m^2/m. WUA is actually a dimensionless parameter that provides an indication of the relative quantity and quality of available habitat at a given flow (Hay 2008[1]).

An important consideration is that the WUA metric provides a relative measure of how predicted habitat changes with flow and that the shape or slope of the WUA curve is more important than its magnitude (Hay 2008[1]). Using the slope of the WUA curve gives an indication of the rate of change of predicted habitat, which can be used to identify the species most sensitive to changes in flow.

The total effect of a proposed management regime can then be seen in context of its relative effects on different fish species.

1.4 History of Ngaruroro Minimum Flow Investigations

The Ngaruroro River was the subject of a physical habitat modeling study in March 1997 as part of the Hawke's Bay Regional Council Sustainable Low Flow Project assessment of the minimum flow (Wood 1998). The survey focused on the reach from upstream of the Maraekakaho Stream confluence to the minimum flow site at Fernhill Bridge.

The 1997 survey report recommended the minimum flow at Fernhill Bridge could be reduced from 2,800 L/s to 2,000 L/s and the proposal was incorporated in the proposed regional Water Plan Variation #2, which was notified in November 1999.

Evidence was presented in hearings on Plan Variation #2 by John Hayes of the Cawthron Institute that identified four significant shortcomings of the 1997 survey report:

- Only riffles and runs were surveyed. This excludes important pool habitat. Local knowledge of the lower river indicates that pool-like features, although they occur less frequently than other habitat types, are present and should be included for a survey reach to be representative of the river environment.

- Braided channels were excluded. Like pools, their presence as a morphological feature of the river should be included for a survey to be representative.

- Only three cross-sections were surveyed in the Fernhill reach. This reach was identified as a critical area, yet the number of cross-sections does not reflect this, and cannot be expected to be representative of the 16 km reach as indicated in the 1997 report. 18 to 20 cross sections are recommended to appropriately model a river reach (Jowett et al. 2008).

- The weighted usable area (WUA) x flow relationships, as simulated, are largely influenced by the upper catchment reaches, which were surveyed at high flows. This tends to flatten the WUA x flow relationship. The lower reaches show a more marked WUA x flow response, but only a small number of cross-sections are available, presenting potential survey bias to model results. The usefulness of the combined survey data are therefore limited.

Additional work for the proposed regional Water Plan Variation #2 indicated that flow loss to the unconfined aquifer was more extensive than measured in the 1997 survey and the minimum flow recommendation could be insufficient to sustain the aquatic ecosystem during low flows. Plan Variation #2 was completed and the proposed Regional Resource Management Plan was publicly notified in April 2000. The minimum flow for the Ngaruroro River was set at 2,400 L/s as opposed to the 2,000 L/s recommendation, based on uncertainties regarding the results of the 1997 survey and to account for flow loss downstream of Fernhill Bridge. This led to the initiation of an additional habitat survey to validate the new minimum flow.

The 2001 survey was carried out on the lower Ngaruroro River from Fernhill Bridge to upstream of the Tutaekuri-Waimate confluence (identified as a critical reach subject to flow loss). A total of 18 cross-sections were surveyed within four reaches: Fernhill Bridge, Hill Road, Carrick Road, and Motorway Bridge. Each cross-section was located where the river flowed within a single, broad-meandering channel. The report stated that the majority of the lower Ngaruroro is characterised by riffle-run sequences with few pools, so justifying only two pools being surveyed.

Modelling was completed using the Rhyhabsim programme. Each cross-section was modelled over a range of flows, with accounts made for flow loss between the four reaches. Available habitat was modeled for both native fish and trout species, and the % weighted usable area (%WUA) was the metric used to gauge habitat with changes in flow (weighted usable area is discussed in more detail in Section 4.3.2). The report from the 2001 IFIM survey indicated that habitat and stream health would not be significantly affected by a decrease in the minimum flow from 2,800 L/s to 2,400 L/s (Wood 2001).

2.0 NGARURORO HYDROLOGY

2.1 Catchment Characteristics

The Ngaruroro Catchment covers an area of approximately 2500 square kilometres, and is the fourth largest catchment in Hawke's Bay (Figure 1). In its headwaters, the Ngaruroro rises from the Kaimanawa Range and flows on the southwest flank of the Kaweka Range. The Taruarau River joins the Ngaruroro as it nears the foothills of the Kaweka Range, providing a significant increase in flow. The majority of runoff from the ranges is recorded at the Whanawhana hydrometric station. Flowing on from Whanawhana, the Ngaruroro becomes increasingly braided before reaching the Maraekakaho Stream confluence.

At this point, significant flow is lost to the unconfined Heretaunga Aquifer between the Maraekakaho confluence and Ohiti. Channel confinement increases downstream with stopbank and gravel beach raking works. Flow loss also occurs between Ohiti and Fernhill. Downstream of Fernhill, the Ngaruroro flows predominantly in a single single-channel during low flow conditions. Minor flow loss also occurs below Fernill.

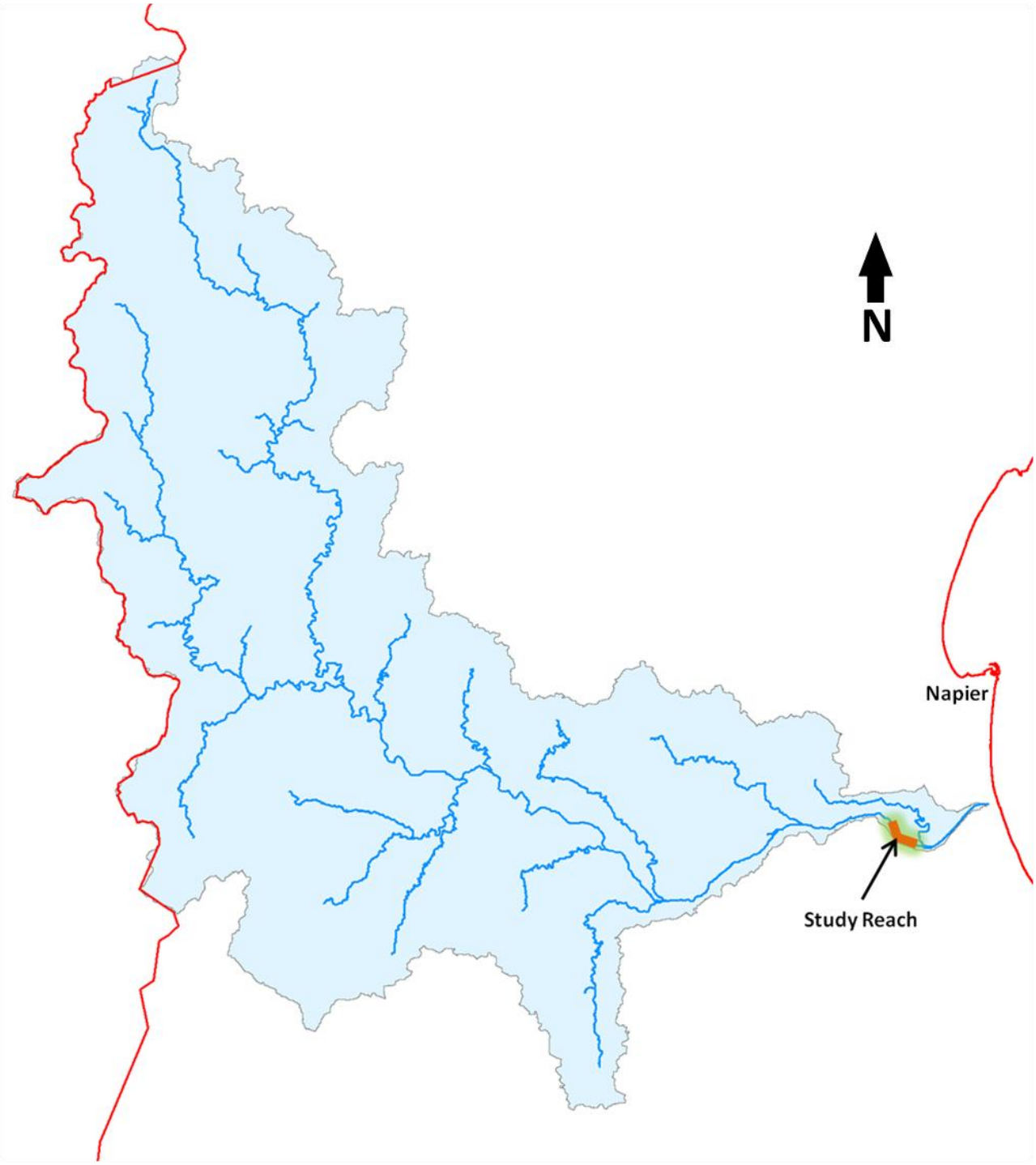

Figure 1: The Ngaruroro catchment and 2009/2010 instream habitat modelling study reach.

2.2 Naturalised Flows

Naturalised flow data were first calculated for the Ngaruroro River as part of the report Flow Naturalisation for Six Hawke's Bay Rivers (Lew et al. 1997). The latest iteration of this work has used actual water usage records to refine the naturalised flow series (Harkness 2010[1]).

The naturalised mean annual low flow has been calculated as a moving mean of the lowest 7-day consecutive flows for each full water year (July to June) for the record 1969 to 2008.

A series of flow statistics including the mean annual low flow have been calculated for the Ngaruroro River at the Fernhill minimum flow site using the naturalised flow series (Table 1).

Table 1: Naturalised flow statistics (l/s) for the Ngaruroro River at Fernhill.

Site	7-day July to June Statistics			November to April Exceedence Percentile Flows		
	Mean	Median	MALF	Q80	Q90	Q95
Ngaruroro @ Fernhill	40114	23662	4548	9467	6930	5066

3.0 REACH SELECTION AND HABITAT MODELLING METHODOLOGY

3.1 Stakeholder Consultation

The habitat modelling process for the Ngaruroro River began with consultation of stakeholders from the Department of Conservation (DOC), Fish and Game New Zealand, and local Iwi representatives. Scientists from National Institute for Water and Atmospheric Sciences (NIWA) and the Cawthron Institute were also consulted for their technical expertise in minimum flow investigations.

A brief discussion memo was circulated to stakeholders to aid understanding of the issues to be addressed in the modelling exercise. This document included information describing the general trends in river gradient, hydrology, and geomorphology along with information on the modelling process and important considerations with using Rhyhabsim. Further stakeholder involvement from DOC staff was carried out during the habitat mapping field work.

3.2 Reach Selection

Reach selection involves selecting the river reach(s) that is (are) the most appropriate for addressing the objectives of the study. There are three major factors that determine the reach(s) to be sampled to provide adequate data for 1D hydraulic habitat models:

- Stream gradient: stream gradient is a primary control on channel morphology and distribution of habitat types.
- Morphology: includes bank confinement, sediment supply and stream flow patterns. In braided systems, the extent of braiding can vary widely between reaches.
- Hydrology: survey reaches should be in areas of consistent hydrology (consistent flow vs gain/loss).

Benchmarked surveys of the Ngaruroro river corridor have been completed by HBRC engineers (Figure 2). The data show a relatively consistent stream gradient from Whanawhana to Fernhill, a significant reduction in gradient at the Fernhill site, and a relatively consistent gradient from the study site to the sea.

The decision was made to focus on the lower Ngaruroro first, both to address issues in previous models and because of the sensitive nature of this section, which receives the least amount of flow after the river crosses the Heretaunga Plains (Figure 2).

The Lower Ngaruroro was defined as the river segment from the Maraekakaho Stream confluence to the sea. This section of river incurs the most resource use (water abstraction, recreation, and food gathering) and also exhibits reduced streamflow as a result of loss to aquifers as the river crosses the Heretaunga Plains.

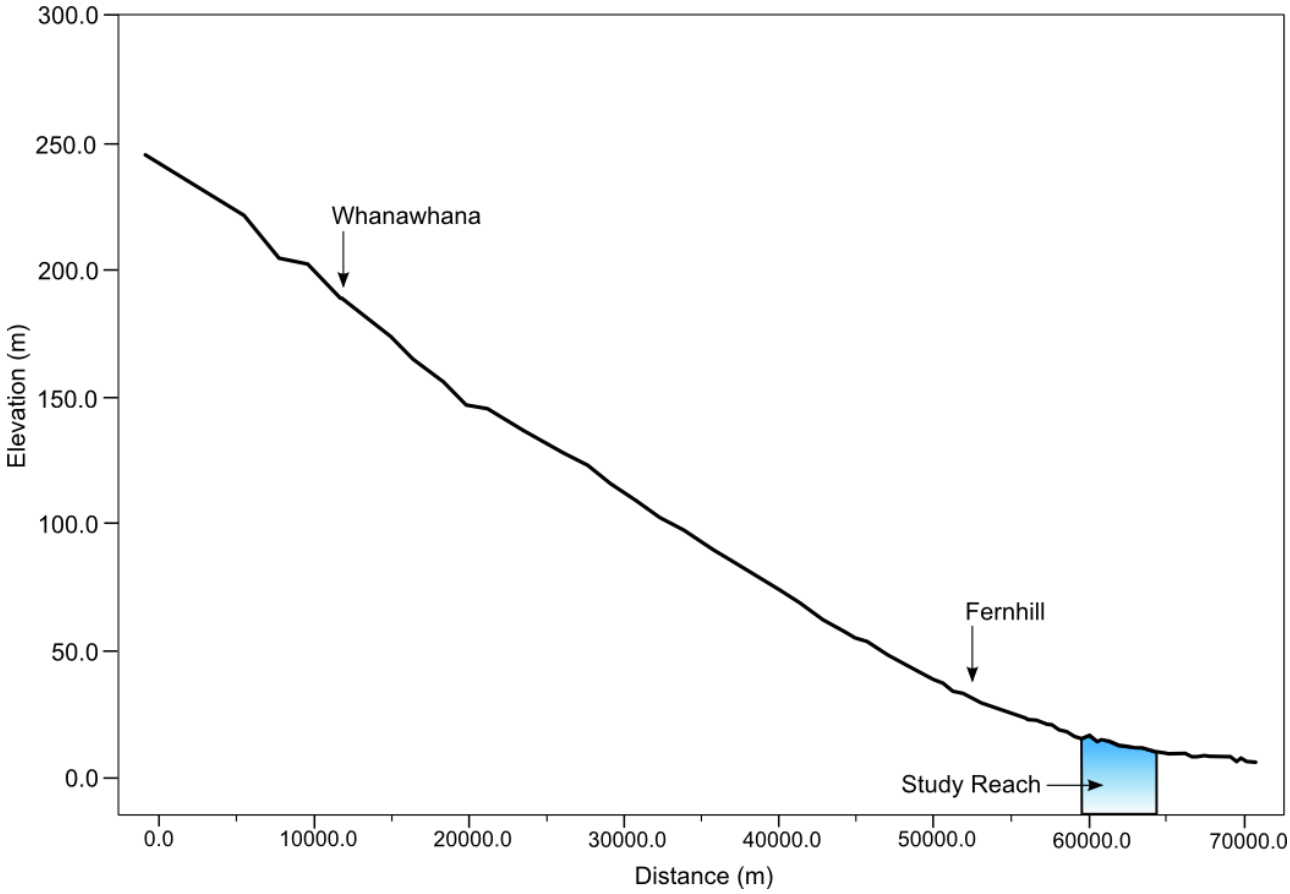

Figure 2: Stream gradient for the Ngaruroro River. Study area indicated by red square.

Aerial photomosaics were used to describe the stream morphology in the lower river (Appendix A). In general, the Ngaruroro is braided along most of its length with the middle reaches exhibiting a greater degree of braiding than the lower reaches. Past the Maraekakaho stream confluence, the braided stream pattern transitions to a predominantly single channel flow. This is most notable below Fernhill. This is likely to be controlled by the change in gradient and river management works (stopbanks and gravel bed raking). As this lowest reach is the most sensitive to low flow conditions, it was chosen as the location for this modelling exercise.

Figure 3: River reach selected for instream habitat modelling of the lower Ngaruroro River outlined in red. State Highway 2 bridge is located at the downstream end of the study reach.

3.3 Habitat Mapping

Habitat mapping is a method for describing the character and distribution of flow types within a river reach, which informs the final structure of the field survey and the weighting applied to individual transects in the model. Typical flow types include riffles, runs and pools. During the habitat mapping exercise, the investigation team walks the study reach, recording the length and description of each flow type. This information is used to build a stratified random sample of flow types. Each sampled flow type is marked with a transect that is measured as part of the field survey.

Representatives from Department of Conservation and HBRC walked the study reach, mapping out different flow types. A consensus was reached that the flow types encountered were best classified into four types; swift run, open run, overhanging run, and backwater. Swift runs were characterised by uniform channel shape, no overhanging vegetation, and higher gradient than other flow types, giving them higher velocities and a slightly rippled water surface (Figure 4). Open runs had uniform channel shapes with no overhanging vegetation, gentle gradients and laminar flow with a smooth water surface (Figure 5). Overhanging runs featured asymmetric channel shapes with a distinct cut bank, deep thalweg, and overhanging vegetation (Figure 6). Extensive backwaters were present in this section, with abundant overhanging vegetation, lengths well in excess of 100 meters, and depths greater than 2 meters, but with no significant flow (Figure 7). Although not true pools, overhanging runs and backwaters were observed to have pool-like features and provide similar habitat.

Stratified random sampling was used to define the location of the model transects.

Table 2: Habitat mapping data for the lower Ngaruroro River.

Flow Type	Swift Run	Open Run	Overhanging Run	Backwater
Length (m)	143	*82	*116	*106

	*147	*289	*90	**350
	*144	*146	*383	*145
	*207	63	*125	*518
	*145	*114	*331	
		*185		
Sub Total (m)	**786**	**888**	**1045**	**1119**
% Total	0.205	0.231	0.272	0.292
Number of Transects	4	5	5	5
Transect Weighting	**5.125%**	**4.62%**	**5.44%**	**5.84%**

*flow type with model transect
**flow type with two model transects

Figure 4: Example of a swift run flow type.

Figure 5: Example of an open run flow type.

Figure 6: Example of an overhang run flow type.

Figure 7: Example of a backwater.

3.4 **Data Collection**

Transects were marked using steel “waratah” pegs on cutbanks well above the water surface to avoid encroaching on river users and to prevent the movement of gravel affecting the level of the peg. These steel pegs acted as benchmarks by which accurate water level measurements could be taken. Wooden pegs were installed on opposite banks to mark the location of the gauging section for consistency between gauging runs.

A critical part of the field work for Rhyhabsim modelling is the measuring of water level on a number of successive gauging runs. HBRC contracted surveyors to obtain water level measurements relative to the steel waretah pegs. This ensured that the most accurate water level measurements were obtained and also allowed gauging teams to gauge flow quickly, which minimised potential changes in flow over the course of a day.

The gauging runs were conducted over a range of flows from slightly less than the MALF (approximately 4000 l/s) to about half the median flow (approximately 13000 l/s). This provided a good range of flows for calibration of the model to allow robust extrapolations to low flows.

3.5 **Data Checking**

Field data were formatted and entered into Rhyhabsim and checked for data quality. The first level of data checking used the built-in checking function in Rhyhabsim to examine habitat weighting, stage at zero flow, and rating curve regression coefficient values. The checking output is reviewed to ensure that all transect weightings add to 100%, that stage at zero flows do not exceed the maximum depth of the transect, and that rating curve regression coefficients are within an acceptable range, using the 95% threshold as a guide.

Cross-sections were then plotted and inspected for obvious errors in depth and velocity. The ratio of measured velocity to calculated velocity is the Velocity Distribution Factor (VDF). VDFs are automatically fitted in Rhyhabsim. Unrealistic VDFs can impact the predicted velocities outside of the measured range. VDFs were checked and edited as per Jowett 2004.

3.6 **Ratings**

The relationship between stage and flow is critical for model outputs to be considered representative of actual river conditions. These relationships, or ratings, are fitted in Rhyhabsim using stage and flow data gathered during field surveys. Three mathematical methods are used to generate ratings, each displayed in Rhyhabsim for a visual check. Transects with robust ratings have plots that are similar for each rating method used.

Two aspects regarding ratings need to be considered. One is that the three calculated rating curves for each individual transect plot similarly. The exponent of the rating used for each transect also needs to be consistent across the entire suite of transects. The recommended range of exponents for rating curves is from 1.5 to 3.5 (Jowett 2004).

Ratings for individual transects fit well between the three rating curve methods. Rating exponents from all but the transect “Backwater 2” fell within the recommended range and had a good degree of fit to gauging data (Figure 7). Backwater 2 was located at the top of the longest backwater segment in the survey reach (518 meters) and it is likely that this part of the backwater is hydraulically disconnected with the main channel and the lower portion of the backwater. This transect is not considered to be critical to or appropriate for the model and has been removed.

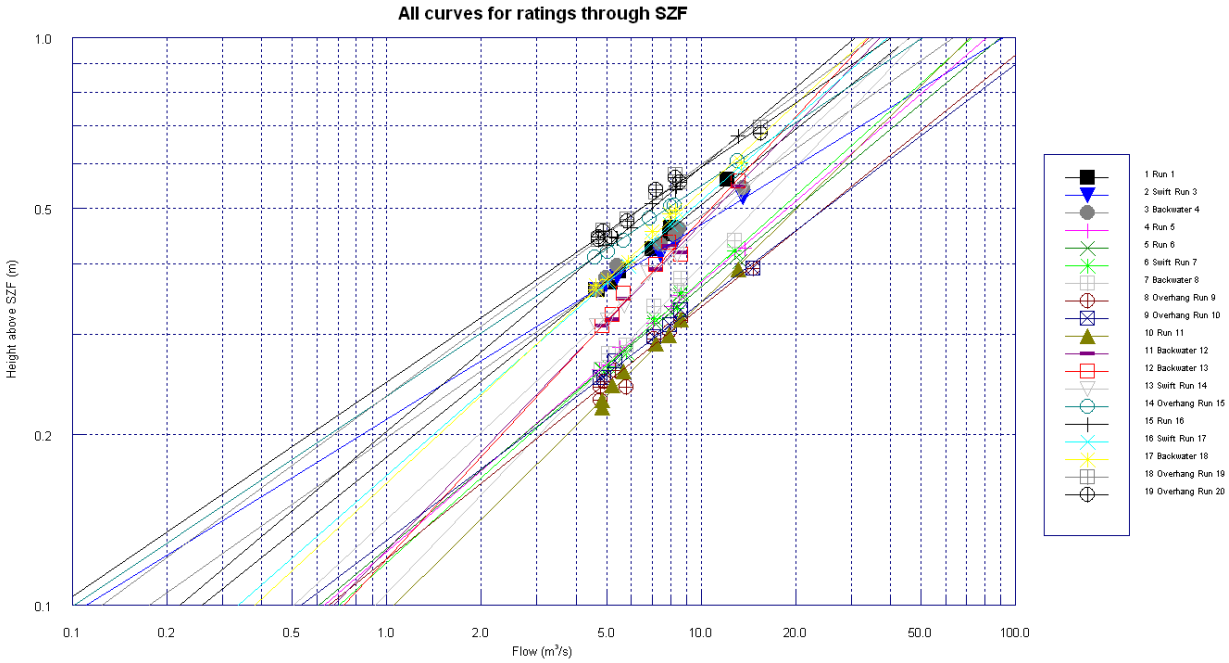

Figure 8: Ratings of all transects in the Ngaruroro River Rhyhabsim model (log-log scale).

3.7 Habitat Predictions

3.7.1 Suitability Criteria

One-dimensional hydraulic habitat model predictions are most sensitive to the habitat suitability criteria (HSC) applied (Jowett 2004). HSC should be chosen which represent the species that occur in the study river, with special consideration made to the types of rivers which the HSC were developed and the type of observations used in the criteria.

Fish and macroinvertebrate species in the Ngaruroro catchment have been compiled (Table 3). Of these species, there are several that may be considered as having high value, either as sport fish or because of their status as a rare or endangered species. The HSC applied in this report are shown in Appendix B.

Rainbow trout make up a significant sports fishery on in the Ngaruroro catchment. The Provisional HB Rainbow trout HSC were developed using data from the Ngaruroro and Tutaekuri Rivers, specifically targeting drift feeding fish >200mm length.

The Ngaruroro River is home to a number of native fish species. The Department of Conservation has released its latest appraisal of the threat classification status of native fish species (Allibone et al. 2010). The threat classification for several native fish species including torrentfish, koaro, and bluegill bully has been changed from "Not Threatened" to "At Risk - Declining". Allibone (2010) states "*It is apparent that more serious effort is now required to reverse the decline in native freshwater fishes and to manage the instrumental causes of their decline that are ongoing, and in some cases increasing, if the extinction of further freshwater fish is to be prevented*." This indicates an increase in the conservation priority on a national level for these species. In addition to the threat classification being increased, these species inhabit areas that are sensitive to changes in flow, an important consideration for this modelling exercise.

Table 3: Fish species in the Ngaruroro catchment. Bold type indicates species with 'At Risk – Declining' threat classifications as per Allibone et al 2010.

Common Name	Scientific Name	Habitat Modelled

Native Fish	**Longfin eel**	***Anguilla dieffenbachii***	**Yes, two size classes**
	Shortfin eel	*Anguilla australis*	Yes, two size classes
	Common bully	*Gobiomorphus cotidianus*	Yes
	Upland bully	*Gobiomorphus breviceps*	Yes
	Torrentfish	***Cheimarrichthys fosteri***	**Yes**
	Redfin bully	***Gobiomorphus huttoni***	**Yes**
	Inanga	***Galaxias maculatus***	**Yes**
	Crans bully	*Gobiomorphus basalis*	Yes
	Common smelt	*Retropinna retropinna*	Yes
	Lamprey	***Geotria australis***	**Yes**
	Koaro	***Galaxias brevipinnis***	**Yes**
	Dwarf galaxias	*Galaxias divergens*	Yes
	Bluegill bully	***Gobiomorphus hubbsi***	**Yes**
	Giant bully	*Gobiomorphus gobioides*	No HSC available
	Black flounder	*Rhombosolea retiaria*	No HSC available
	Yelloweyed mullet	*Aldrichetta forsteri*	No HSC available
	Grey mullet	*Mugil cephalus*	No HSC available
Sports Fish	Rainbow trout	*Oncorhynchus mykiss*	Yes, two size classes
	Brown trout	*Salmo trutta*	Yes, two size classes
Crustacea	Koura	*Paranephrops planiforms*	No HSC available
Insecta	Mayfly	*Deleatidium spp.*	Yes
	General Macroinvertebrate		Yes

***Not recorded in catch data, but high likelihood of presence; HSC used in model.**

3.7.2 Modelled Flow Range

The USGS Biological Resources Division Phabsim training document suggests that the Phabsim hydraulic model can be extrapolated up to 1.5 times the highest measured flow and down to 0.6 times the lowest calibration flow (Milhous et al. 1989). They state that the absolute maximum range for extrapolation is from 2.5 times the highest calibration flow and 0.4 times the lowest calibration flow. It is reported that the rating curve development functions of Rhyhabsim improve upon those found in Phabsim (Hay 2008[2]). For consistency, the range of flows modelled in this report has been kept within the USGS maximum recommended range.

4.0 RESULTS

The results of Rhyhabsim modelling on the Ngaruroro River have been compiled (Table 4). Flow levels have been presented for each modelled species which provide four levels of habitat WUA, ranging from the WUA optimum to 70% of habitat availability (either from the optimum or from the WUA at the MALF, whichever less). A selection of species have been highlighted which are likely

to be of significant importance to regional stakeholders, thus forming pertinent management objectives for setting the minimum flow.

Table 4: Flows providing a range of habitat WUA retention levels for species modelled in the Ngaruroro River. Potential management species indicated in bold. HSC are from Jowett and Richardson (2008) unless otherwise noted.

NGARURORO RIVER		Retention levels for WUA at MALF or optimum WUA flow (whichever less)		
Habitat Suitability Criteria	Flow at WUA Optimum (l/s)	90%	80%	70%
Longfin eel <300mm (Jellyman et al 2003)	!	2900	1400	**
Longfin eel >300mm (Jellyman et al 2003)	!	1900	**	**
Longfin eel <300mm (Jowett & Richardson 2008)	5100	2700	2000	**
Longfin eel >300mm (Jowett & Richardson 2008)	6000	2800	1900	**
Shortfin eel <300mm	3600	1200	**	**
Shortfin eel >300mm	3700	2000	1200	**
Common bully	2600	1200	**	**
Torrentfish	**9500**	**4200**	**3900**	**3400**
Redfin bully	2500	1200	**	**
Inanga feeding	**	**	**	**
Crans bully	1400	**	**	**
Smelt	4100	2700	2200	1800
Lamprey	**	**	**	**
Koaro	**5200**	**2900**	**2200**	**1700**
Dwarf galaxias	2300	**	**	**
Bluegill bully	**6000**	**3900**	**3400**	**2800**
Rainbow trout <100mm	1300	**	**	**
Rainbow trout >200mm (Provisional Hawke's Bay HSC)	**!**	**3900**	**3400**	**2700**
Brown trout <100mm	4800	2200	1600	1200
Brown trout adult (Hayes and Jowett 1994)	**!**	**4000**	**3500**	**3000**
Mayfly (Jowett and Richardson 1990)	9700	3200	2100	1300
General Macroinvertebrate (Waters 1976)	!	4000	3600	3200

!Flow at WUA optimum exceeds modelled range

****Flow at specified WUA value is less than modelled range**

4.1 Trout Habitat

Rainbow trout are considered a high-priority management species in the Ngaruroro. Several aspects of rainbow trout make them important species to consider, including their high flow requirements and sport fishing status. Recent work by the Cawthron Institute, Fish and Game New Zealand, and HBRC has been completed to develop habitat suitability criteria for rainbow trout in Hawke's Bay rivers. Brown trout also make up a small, but significant fishery in the lower river, where large sea-run fish are highly prized.

Weighted usable area (WUA) response curves have been calculated in Rhyhabsim (Figure 8). WUA increases throughout the modelled range for adult trout. This indicates that the natural low flow conditions in the Ngaruroro River are limiting for adult trout habitat. Juvenile trout habitat reflects the lower depth and velocity requirements of this life stage. Optimum habitat peaks at very low flows for juvenile rainbow trout and at flows near the MALF for juvenile brown trout.

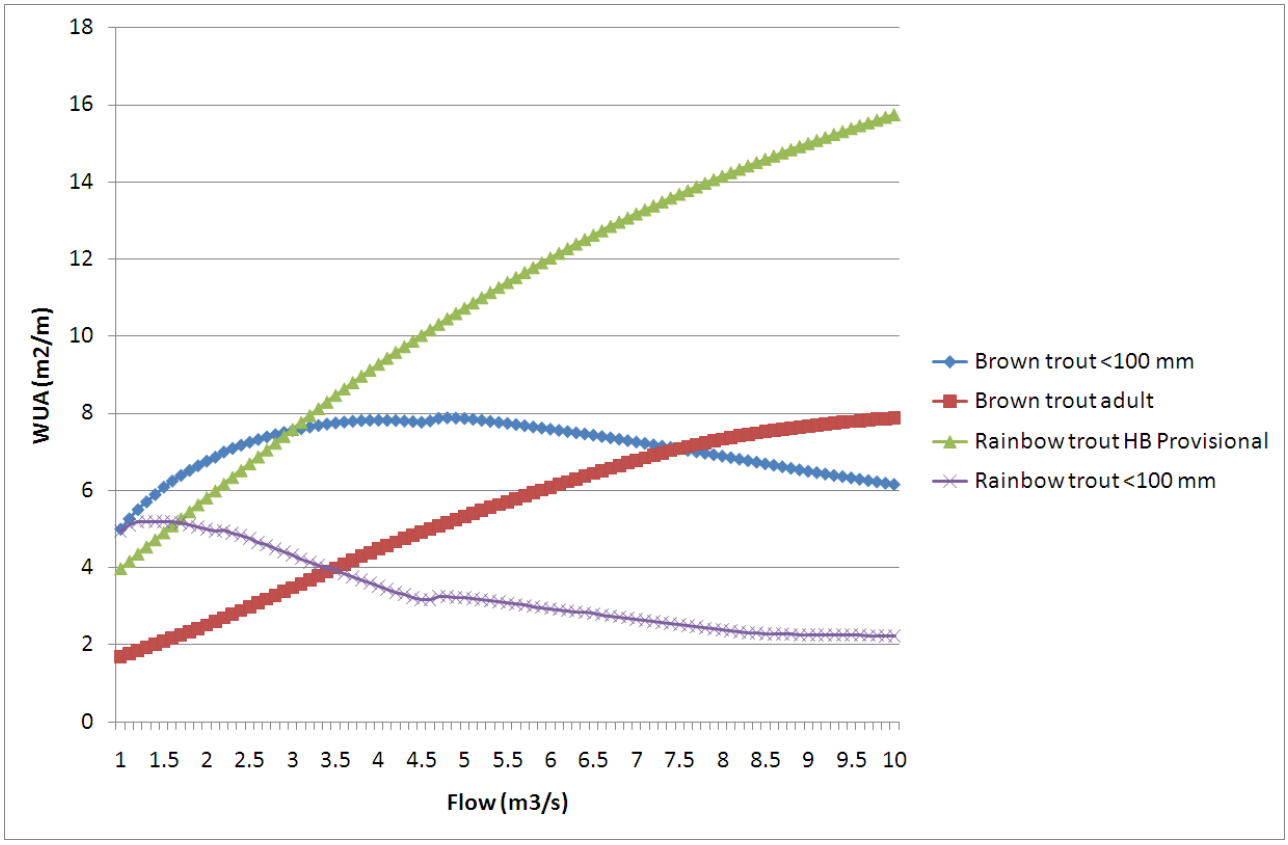

Figure 9: Rainbow and brown trout habitat WUA responses.

4.2 Native Fish Habitat

Model results for longfin and shortfin eels are shown in Figure 9. Two sets of habitat suitability criteria are available for longfin eel (Jellyman et al. 2003 and Jowett and Richardson 2008) and one set of HSC for shortfin eel (Jowett and Richardson 2008). The Jellyman curves for longfin eels show a relatively flat, but steady increase in habitat WUA over the modelled range of flow. The Jellyman habitat suitability criteria have higher velocity optimums than the more recent Jowett and Richardson HSC, thus giving them a higher flow for optimum habitat WUA.

The Jowett and Richardson longfin eel HSC show that both size classes have optimum flows between 5000 and 6000 l/s, with relatively sharp declines in habitat WUA below the optimum flow and relatively gentle declines in habitat WUA above the optimum flow.

Shortfin eel curves show similar responses between the two size classes, with optimum WUA at lower flows than for longfin eels. The larger size class of shortfin eels shows a more sensitive response to changes in flow, with a relatively steep decline in habitat below the optimum.

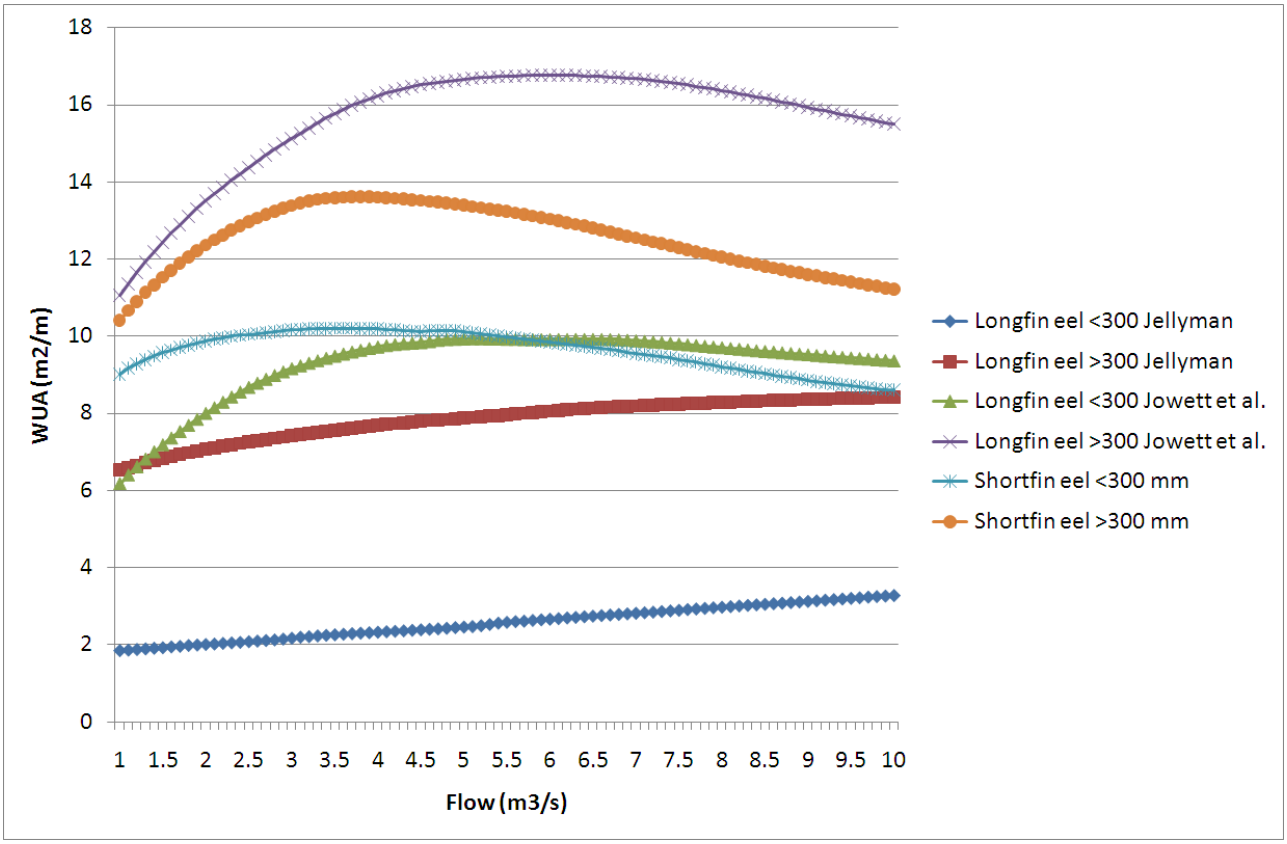

Figure 10: Longfin and shortfin eel habitat WUA responses.

The habitat WUA responses for native species with high flow requirements was compiled including bluegill bully, koaro, smelt, and torrentfish (Figure 10). Smelt have the highest WUA of the modelled suite and a very sensitive response to decreases in flow below 3000 l/s. Torrentfish and bluegill bullies show the next most sensitive flow response, but have higher optimum flow requirements (in excess of 6000 l/s). The WUA response for koaro is relatively flat with an optimum flow of 5200 l/s.

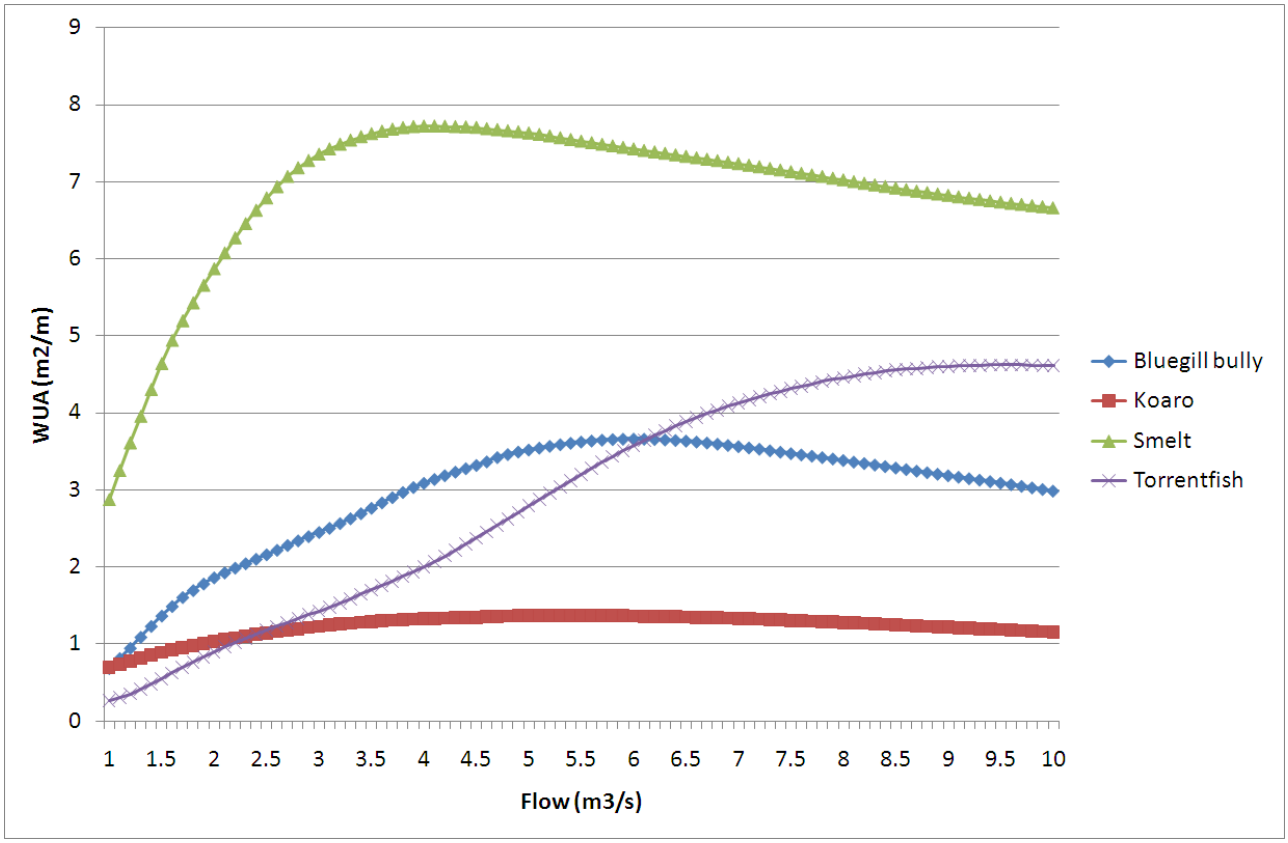

Figure 11: Habitat WUA responses for bluegill bully, koaro, smelt, and torrentfish.

Several native species in the Ngaruroro River seek out shallow, slow moving water as their preferred habitat. Those modelled include common bully, crans bully, dwarf galaxias, lamprey, and redfin bully (Figure 11). All species show a similar WUA response with an optimum flow near the low end of the modelled range and a moderate decline in habitat at greater flows. Indications are that abundant habitat is available for common, crans, and redfin bullies, with less overall habitat available for dwarf galaxias and lamprey.

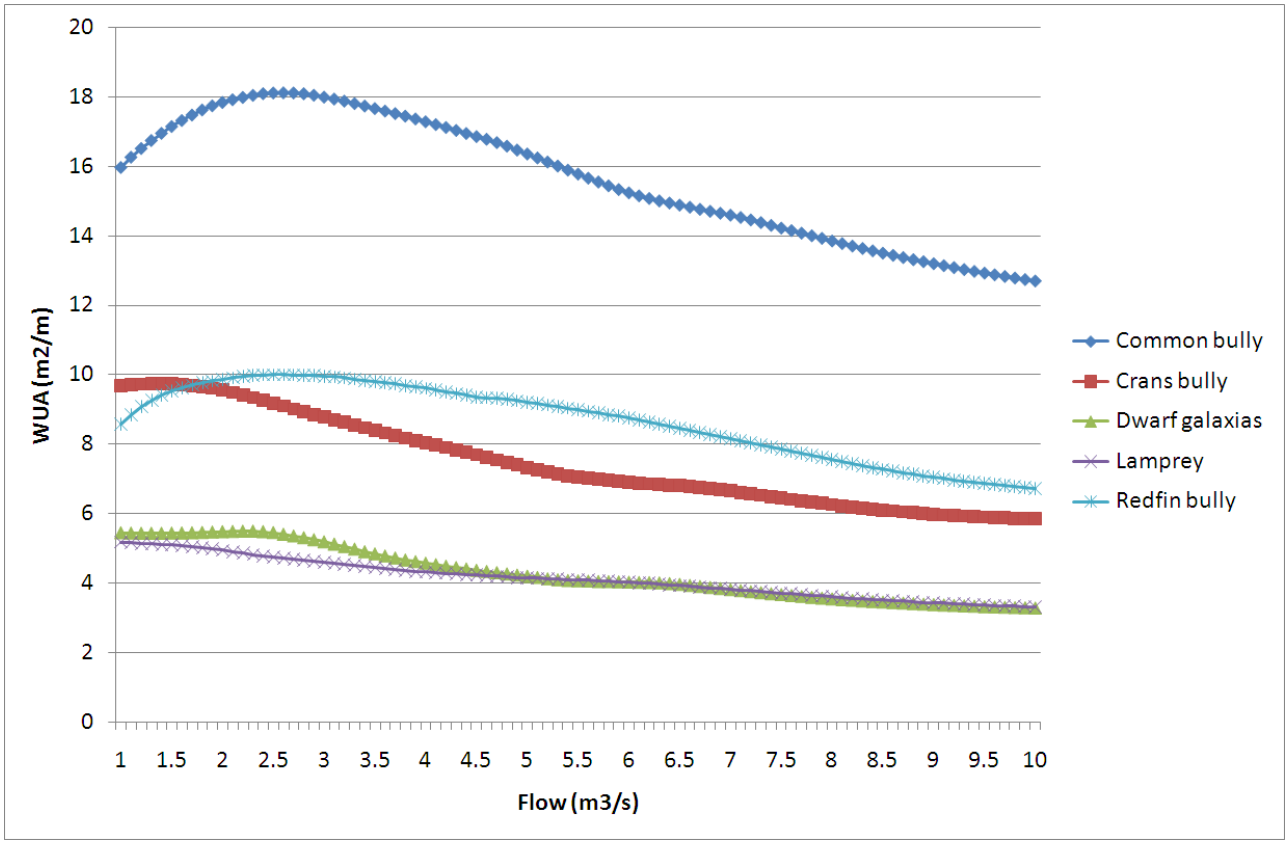

Figure 12: Habitat WUA responses for common bully, crans bully, dwarf galaxias, lamprey, and redfin bully.

5.0 DISCUSSION

5.1 Ecological Relevance of the MALF

The mean annual low flow is an important hydrological parameter for long-lived fish and other river inhabitants with annual reproduction cycles (Jowett 1990, 2002, Clausen and Biggs 1997, Jowett et al. 2005, Booker et al. 2008). The lowest flow of each year acts as a bottleneck on instream habitat, thus affecting the living space of fish and other instream fauna. The mean annual low flow describes the magnitude of the expected low flow event for any given year, giving water resource managers a benchmark from which to make management decisions.

This relationship between MALF and fish habitat is often recognised in flow management. It has become common practice to interpret WUA curves in conjunction with the MALF. Where the optimum WUA for a given species is greater than the MALF, then it follows that MALF is a limiting factor for that species' habitat. Managers can attempt to bridle the effect of water takes increasing that limitation by restricting the drawdown of rivers below MALF to maintain a percentage of WUA available at the MALF.

5.2 Reconciling Flow Requirements of Multiple Instream Values

Typical instream habitat models include a range of species, each with its own unique life history, habits, and flow requirements. The process of flow management must reconcile these different and often conflicting flow requirements to provide protection for a range of instream values. Jowett and Hayes (2004) suggest identifying the critical instream values (fish species in this case) and managing for those values. Critical values may include rare or endangered fish species or highly valued sport fish with high flow requirements, under the assumption "that by providing sufficient flow to sustain the most flow sensitive, important value (species, life stage, or recreational activity), the other significant values will also be sustained" (Jowett & Hayes 2004, p. 8).

Habitat WUA can be used as the measurement tool for managing critical values by choosing a level of available habitat to be retained (based on either optimum WUA or WUA at the MALF, whichever is least). The level of habitat retention is ultimately an arbitrary value. The current scientific understanding of river ecosystems and fish populations is insufficient to identify levels of habitat below which detrimental effects will occur (Hay 2008[2]). The level of habitat retention is therefore based more on risk management (Jowett and Hayes 2004) with greater risk of detrimental effects on populations with increasing habitat loss. Where a range of values are present with varying importance, the level of habitat retention can then be varied according to the importance of the value. Suggested levels of habitat retention for a range of values were provided by Jowett and Hayes (2004) and have been included here (Table 5).

Table 5: Suggested significance ranking and levels of habitat retention of critical species values. From Jowett and Hayes 2004.

Critical Value	Fishery quality	Significance ranking	% habitat retention
Large adult trout – perennial fishery	High	1	90
Diadromous galaxiid	High	1	90
Non-diadromous galaxiid	-	2	80
Trout spawning/juvenile rearing	High	3	70
Large adult trout – perennial fishery	Low	3	70
Diadromous galaxiid	Low	3	70
Trout spawning/juvenile rearing	Low	5	60
Redfin/common bully	-	5	60

Weighted usable area expressed as a percentage (%WUA) was included in early version of Rhyhabsim to give an indication of relative habitat quality and to allow comparisons between hydrologically dissimilar catchments. On some occasions, the %WUA metric has historically been mistaken as a quantitative measure, leading to the metric being changed in newer versions of Rhyhabsim to a habitat suitability index (HSI, ranging from 0 to 1) in an attempt to reduce confusion around interpretation. Current methods of interpreting Rhyhabsim outputs for minimum flow setting focus on WUA as this metric is a quantitative measure which takes into account both habitat quality and quantity (Hay 2008[2]).

Most recent habitat modelling exercises in New Zealand have used the most sensitive species as the benchmark for setting minimum flows, assuming that all other species habitat will be provided for. Native fish habitat requirements have often been modelled to be less than those for trout (except some fast-water species). Recommendations for percent retention of native fish habitat WUA have often been less than that for trout. Explicit protection of native fish habitat is not commonly the primary management objective in most minimum flow setting exercises. When applied, most cases have recommended retention of 60%-70% of the habitat WUA available at the MALF for native species (versus 80-90% for trout).

Jowett and Hayes (2004) raise two points regarding fast-water native fish, including torrentfish and bluegill bullies. The first suggests these species have relatively low instream value as they do not comprise sport or customary fisheries, although some customary fisheries for torrentfish have been documented (McDowall 2000). Further evidence is presented for their resilience to environmental changes, noting that most are diadromous and likely to be recruited from a regional gene pool. This would give them resilience to flow changes within a single river. This evidence supports the contention that lower habitat retention levels may be sufficient to support native fish populations.

Significant flow reductions (below the naturalised MALF) on several rivers in the region may impact on regional native fish populations. The minimum flows of all rivers within the region should then be considered when addressing the habitat retention levels of diadromous native species. The current minimum flows relative to MALF for the major Hawke's Bay catchments show that there are considerable reductions below MALF on some of the major Hawke's Bay rivers (Table 6), with minimum flows on average 37% less than MALF.

The increase in threat status of native fish along with the current state of minimum flows relative to the MALF provides support for high levels of habitat retention of native fish species to mitigate risk to native fish populations through habitat loss.

Table 6: Percent difference between mean annual low flows and minimum flow levels for major catchments in Hawke's Bay.

River	MALF (l/s)	Minimum Flow (l/s)	Minimum Flow as % MALF
Wairoa	19,300	No minimum flow	-
Mohaka	23,000	No minimum flow	-
Esk	2,100	1,400	67%
Tutaekuri	*3,800	2,000	53%
Ngaruroro	*4,500	2,400	53%
Karamu	*1,300	1,100	85%
Tukituki	*6,400	3,500	55%
Maraetotara	350	220	63%
Porangahau	N/A	No minimum flow	-

*Naturalised 7-day July-June MALF

N/A: Data not available

5.3 Minimum Flow Setting Process

There are many considerations to be made in the minimum flow setting process, the most important of which is defining the values that the community wishes to maintain or enhance. It is not the intention of this report to define those values as that process involves all stakeholders in

the Ngaruroro catchment. However, there are many National and Regional examples to guide recommendations in this report, which have been incorporated.

One of the longstanding management objectives in the major Hawke's Bay catchments is maintaining high quality rainbow trout fisheries. Rainbow trout have been a prominent management species for the Ngaruroro River in the past; however the importance of native fish habitat is becoming an increasingly discussed topic. The newest report on the threat status of New Zealand native fish (Allibone et al. 2010) has indicated a heightened importance on preserving habitat for a number of native species present in the Ngaruroro River system.

It is recognised that for some rivers, the flows required to maintain 90% habitat retention for critical species are significantly higher than the current minimum flows in the Regional Resource Management Plan. It is recommended that a thorough consultation of regional stakeholders be held to discuss the goals for management of the Ngaruroro catchment, with clear outcomes defined for the maintenance of fish habitat. The results from this modelling exercise can then be used to determine the flow that best meets the needs of all stakeholders.

5.4 **Allocation Limits**

Minimum flows define the low flow limit below which water abstraction from rivers must cease. To ensure that detrimental ecological effects do not occur due to increases in the frequency and duration of the minimum flow, limits are placed on the amount of water allocated from a catchment. These allocation limits restrict the amount of total allocation, often in terms of both instantaneous rate of take and total volume. By placing limits on water allocation, flow variability within the natural hydrograph can be protected, in turn protecting ecological function related to flow variability (Bergey 1998, Clausen and Biggs 1997, Duncan and Woods 2004, Jowett et al. 2005, MfE 2008, Richter et al. 1996, Richter et al. 1997, Richter et al. 1998, Smeltzer and Lassettre 1999).

Allocation limits can be placed at different parts of the hydrograph to create "blocks" of water available for allocation, each with its own security of supply. The minimum flow and core allocation limit define the "core allocation" and additional higher minimum flows and high flow allocation limits define additional allocation blocks. This is a commonly used system for water allocation in New Zealand. An idealised schematic describes allocation limits as part of a water management regime (Figure 13).

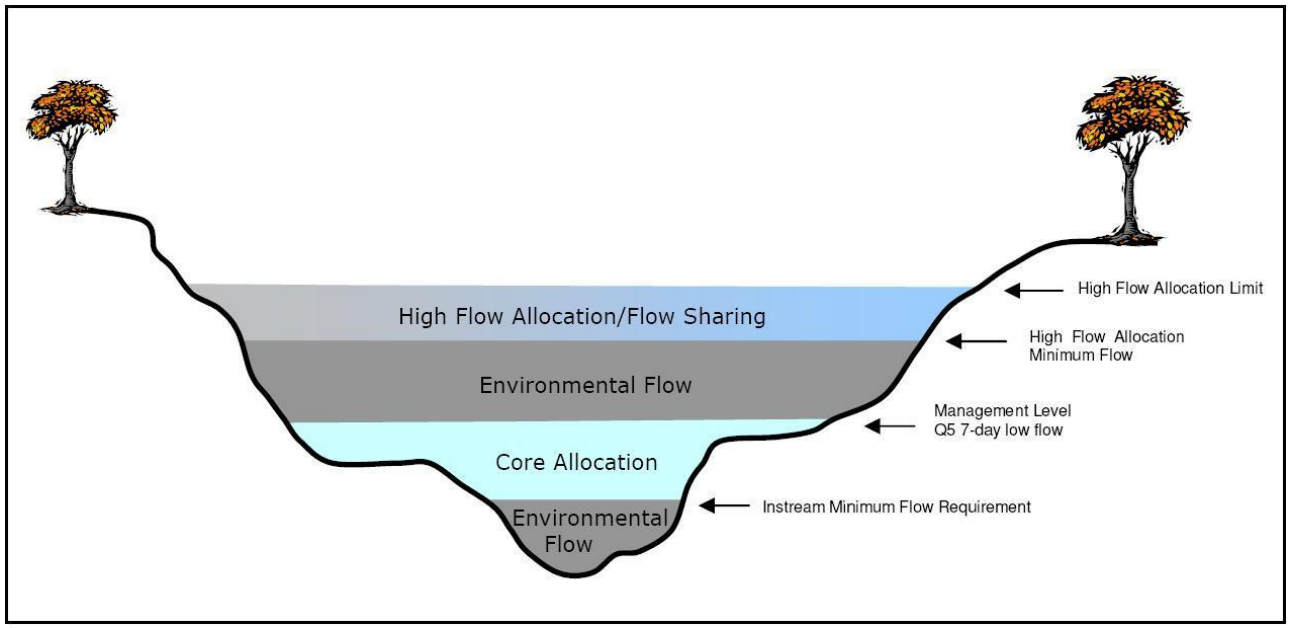

Figure 13: Schematic showing an idealised water allocation regime. From Harkness (2010[2]).

Allocation limits must be used in conjunction with minimum flows to account for a variety of instream habitat requirements. Allocation limits for the Ngaruroro catchment will be addressed in subsequent HBRC publications, presenting various allocation scenarios and their respective impact on the flow regime.

6.0 CONCLUSIONS

This report describes the application of the Rhyhabsim instream habitat model to assess the instream flow requirements for the lower Ngaruroro River. Habitat WUA versus flow relationships produced using Rhyhabsim have been presented. The interpretation of the WUA versus flow relationships followed the process:

- Suggested critical values were identified as the species or life-stage that has the highest fishery or conservation value and the highest flow requirements. It is assumed that the any minimum flow intended to protect habitat for these species will also accommodate species or life-stages with lower flow requirements.
- The habitat retention level for each critical value was referenced to the MALF or to the optimum flow, whichever was lowest
- A level of habitat retention was chosen which is likely to sustain the critical values

Potential minimum flows presented in this report are based on maintaining 90% of the habitat available at the MALF for several sport and native fish species. It is important that up-to-date stakeholder consultation is incorporated in identifying critical management targets for the Ngaruroro catchment. Where agreed targets are different from past management objectives, the full model outputs are available to define the flow that best achieves those targets.

The primary flow setting objective for many of the major Hawke's Bay rivers has been providing sufficient physical habitat for the rainbow trout fishery. This has been successfully adopted because of the local support for recreational angling and the high flow requirements of trout, which have been accepted in many cases to provide ample flows for sustaining native species. It is anticipated that the rainbow trout fishery will continue to have a high standing in the list of management objectives for the Ngaruroro River.

Additional values including native fish have also been considered and model results provided accordingly. It is recommended that a full assessment of the values of the lower Ngaruroro be completed and considered in conjunction with the model results. Habitat WUA for a range of species can then be used as a currency for the setting of the minimum flow. The risk of habitat reduction for each valued species can be described by the rate of reduction of habitat WUA below the mean annual low flow. The importance of the relative values of the lower Ngaruroro can guide water managers to determine the best balance of habitat retention levels.

A summary table has been compiled with potential minimum flows, based on retaining 90% of habitat available at the MALF for the most flow demanding sport and native fish species in the Ngaruroro catchment (Table 7).

Table 7: Flows required to retain 90% of habitat available at the MALF for rainbow trout and torrentfish.

Critical HSC	Habitat Retention Level	Flow that Provides 90% Habitat Retention at the MALF (l/s)
Rainbow Trout >200mm (Provisional Hawke's Bay HSC)	90%	3900
Torrentfish (Jowett and Richardson 2008)	90%	4200

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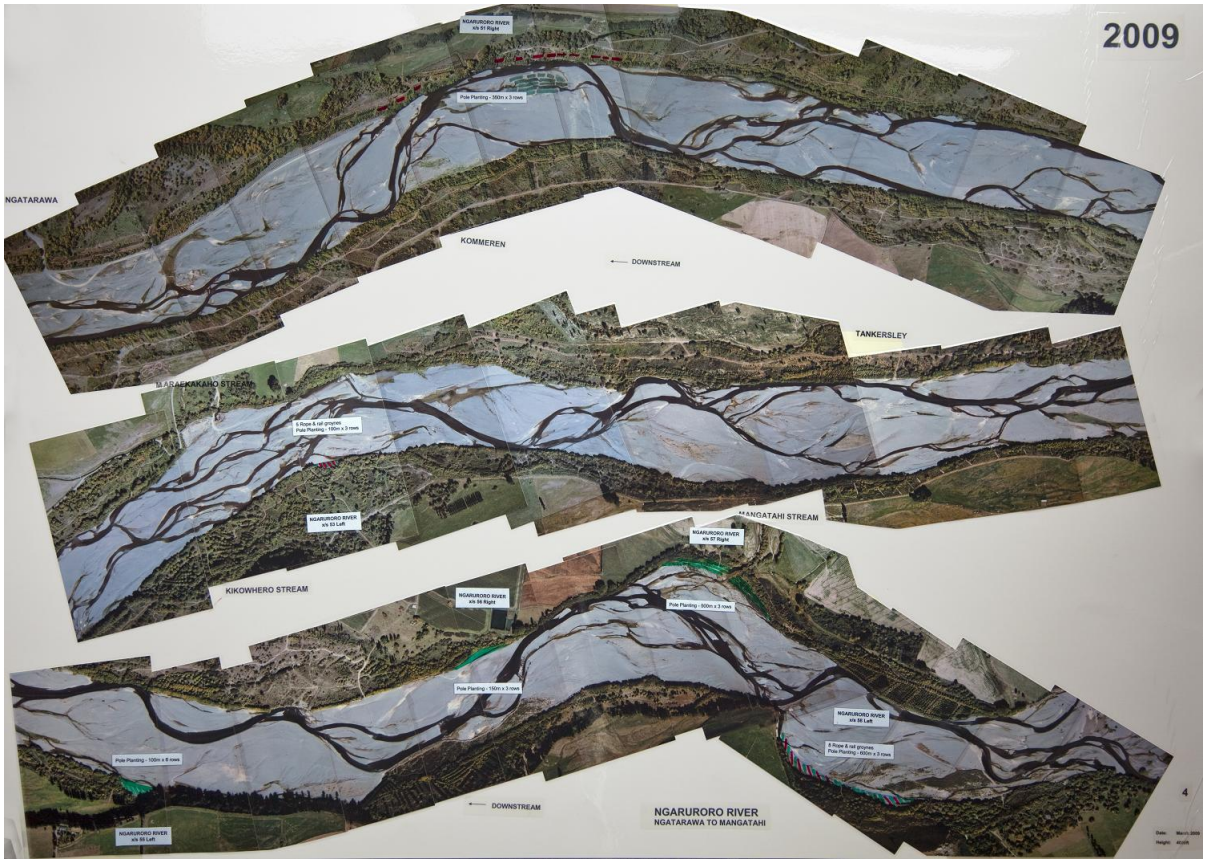
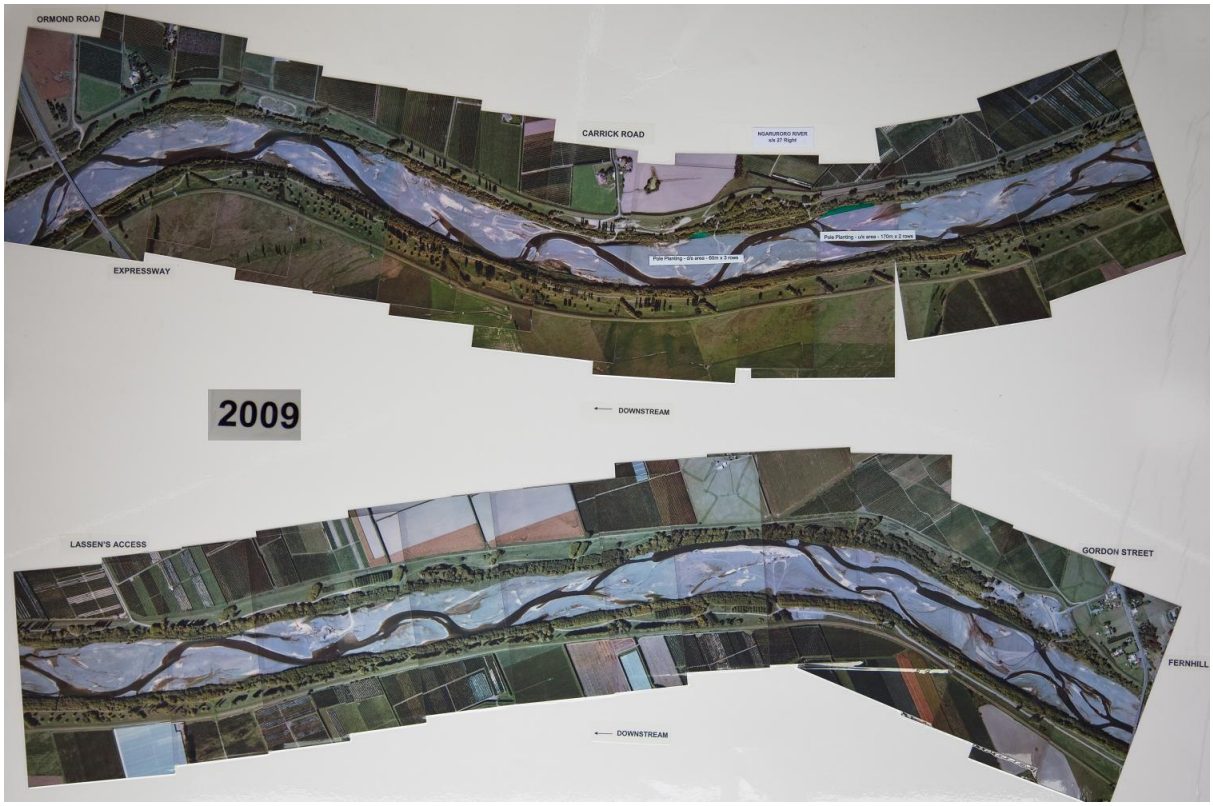
APPENDIX A: NGARURORO AERIAL PHOTOMOSAICS

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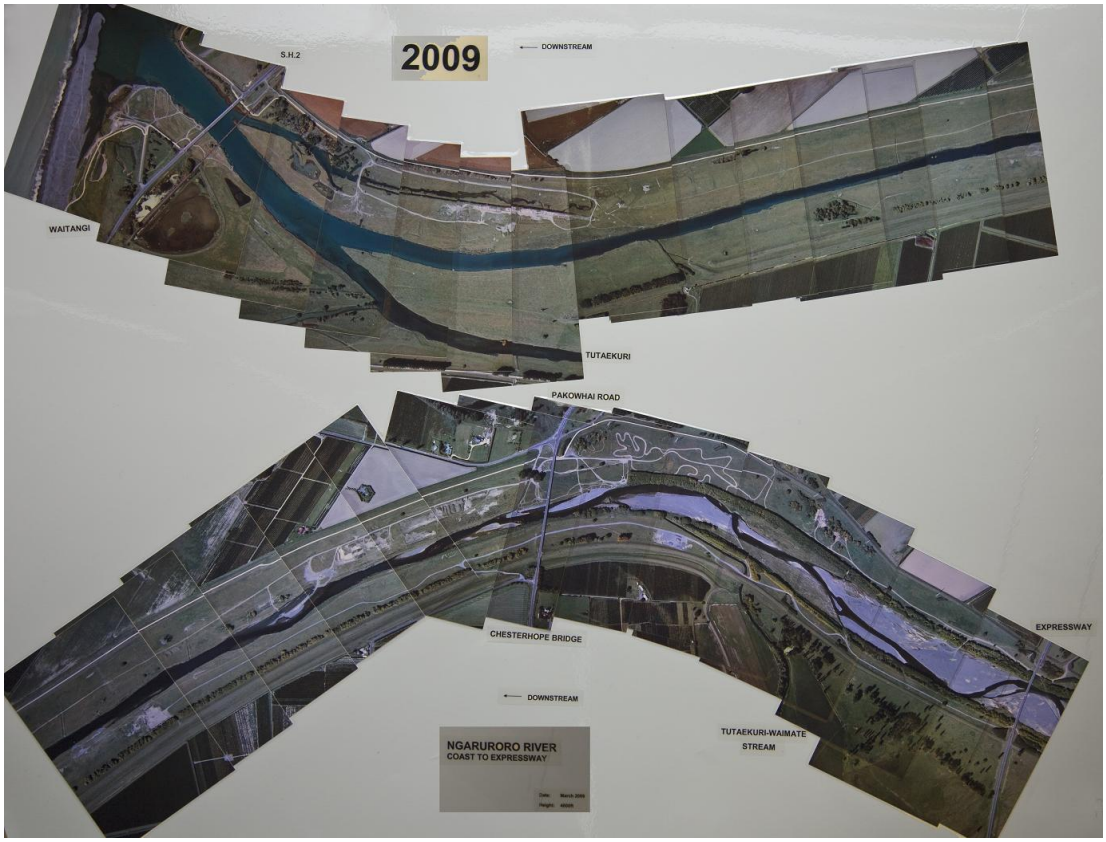
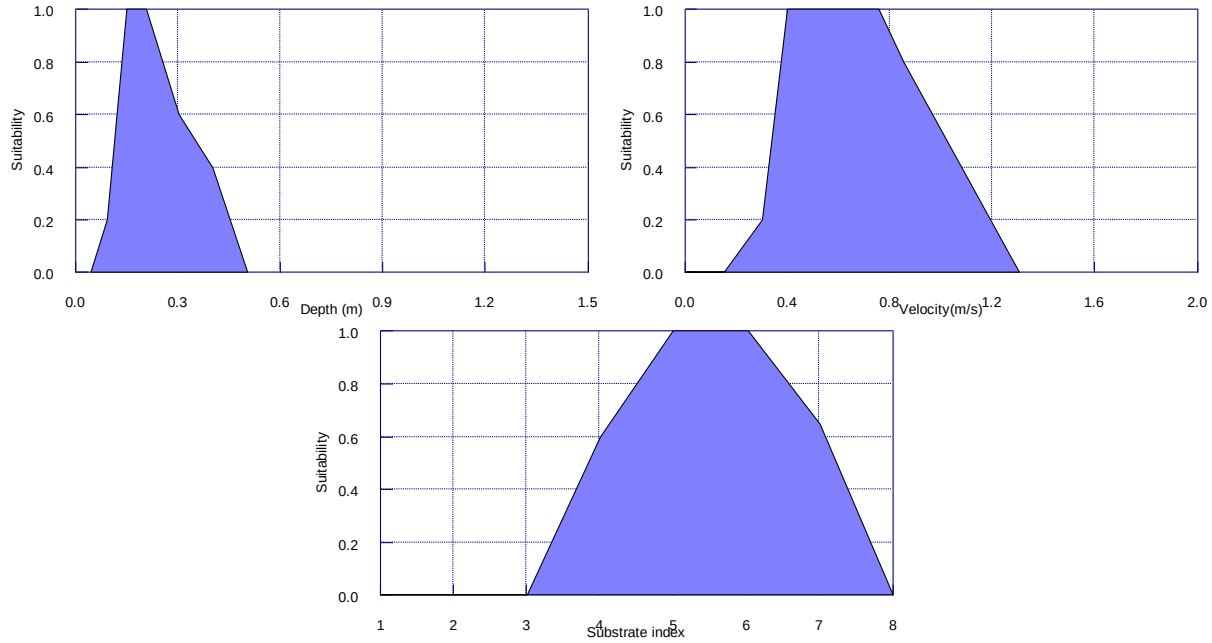
CARRICK ROAD
EXPRESSWAY
2009
DOWNSTREAM
LASSEN'S ACCESS
GORDON STREET
FERNHILL
DOWNSTREAM

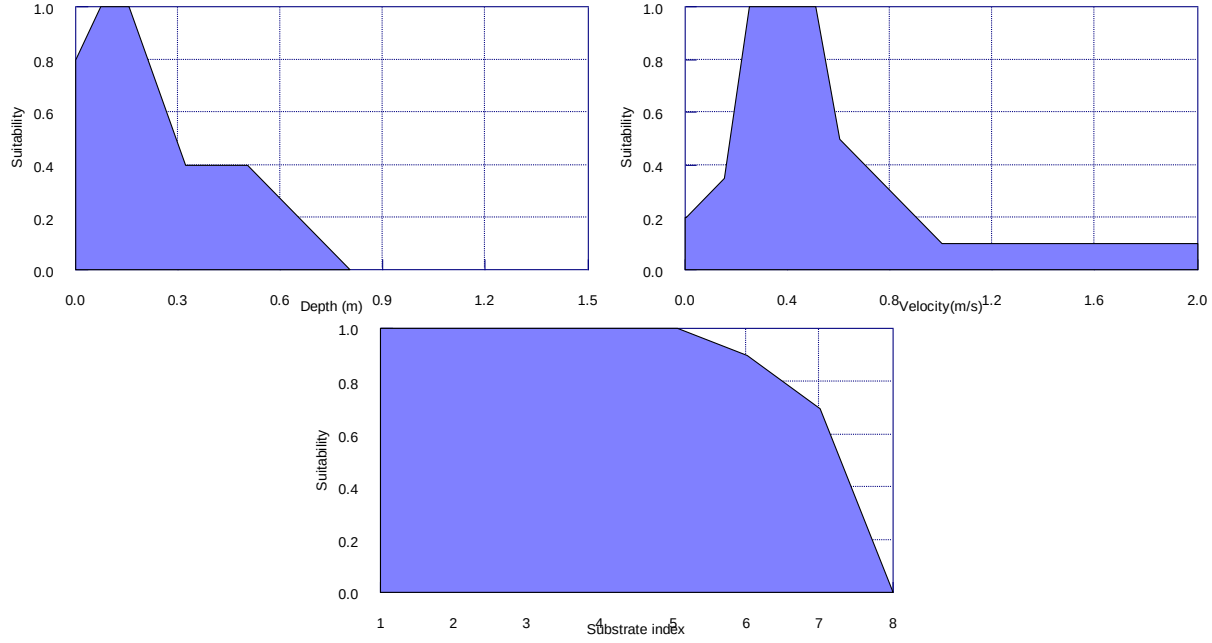

S.H.2
2009
DOWNSTREAM
WAITANGI
TUTAEKURI
PAKOWHAI ROAD
CHESTERHOPE BRIDGE
EXPRESSWAY
DOWNSTREAM
TUTAEKURI-WAIMATE
STREAM
NGARURORO RIVER
COAST TO EXPRESSWAY

APPENDIX B: HABITAT SUITABILITY CRITERIA

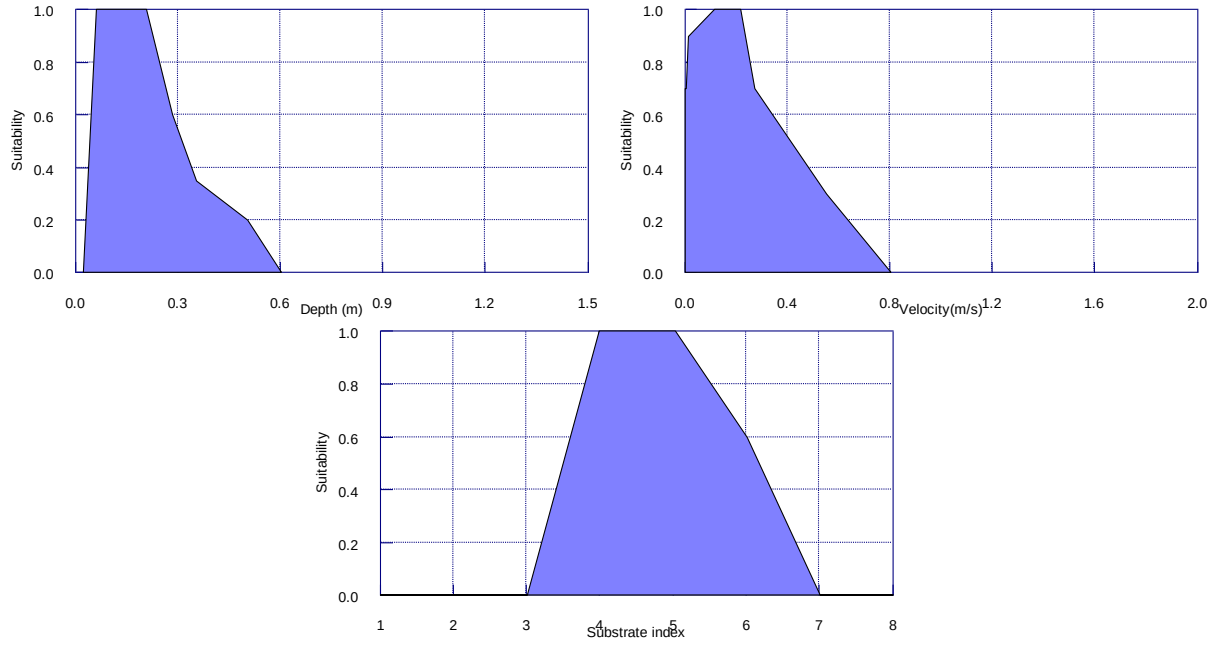
Bluegill bully (Jowett & Richardson 2008)



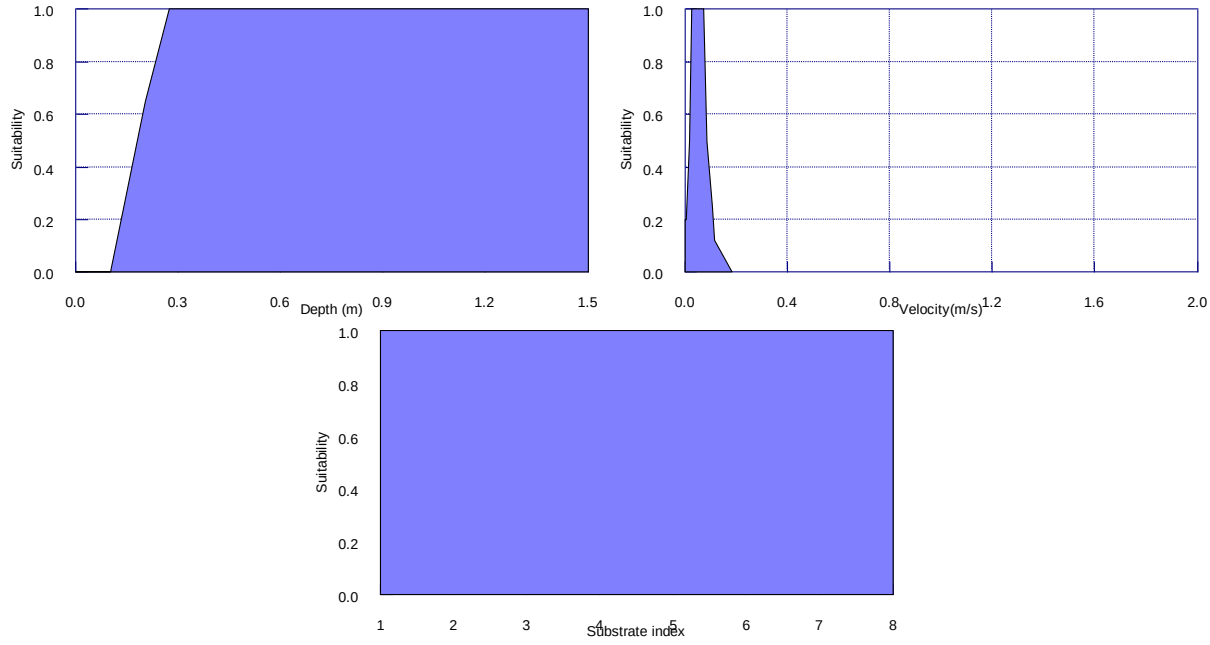
Common bully



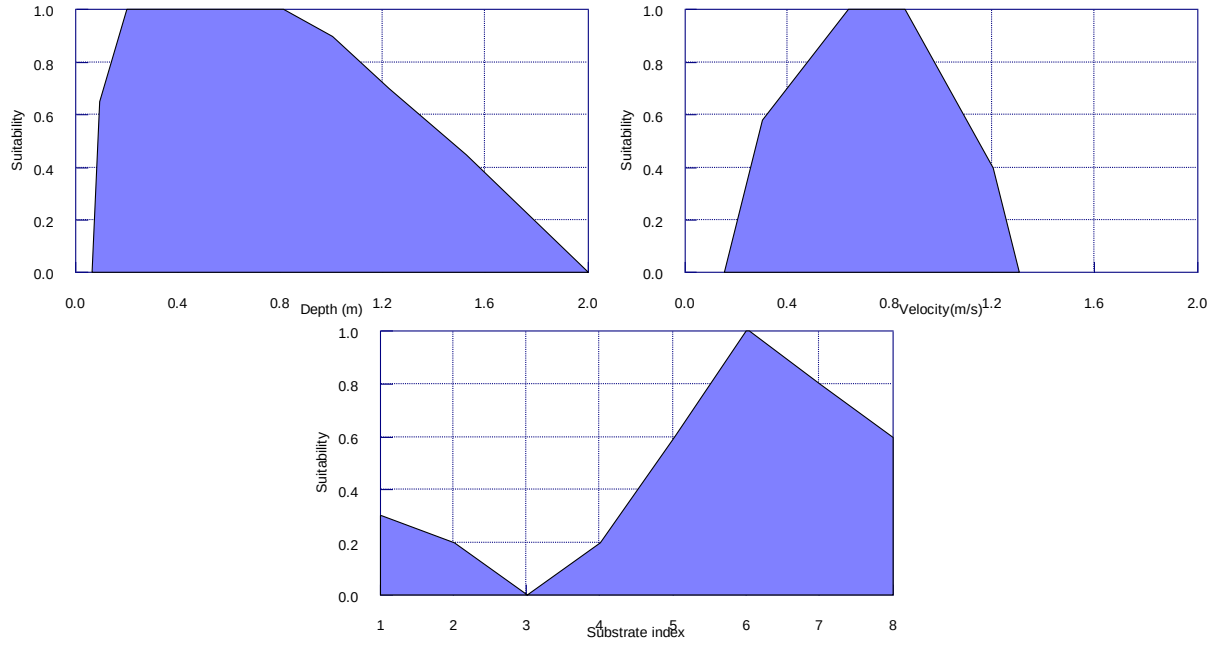
Crans bully (Jowett & Richardson 2008)



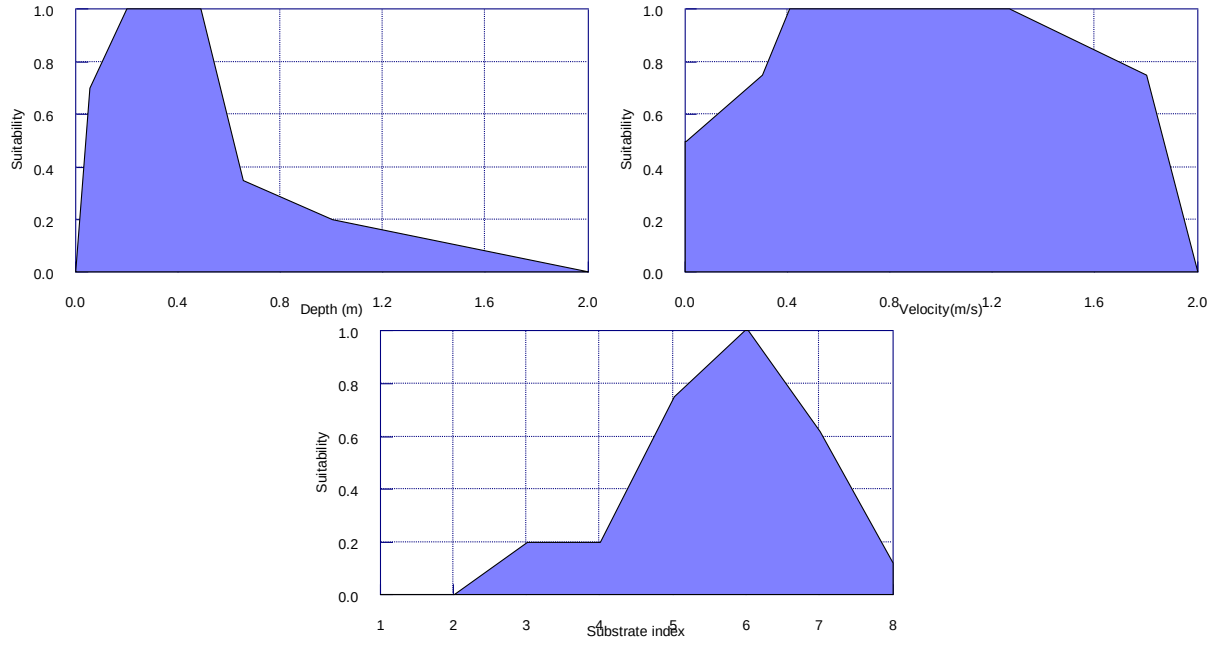
Inanga feeding



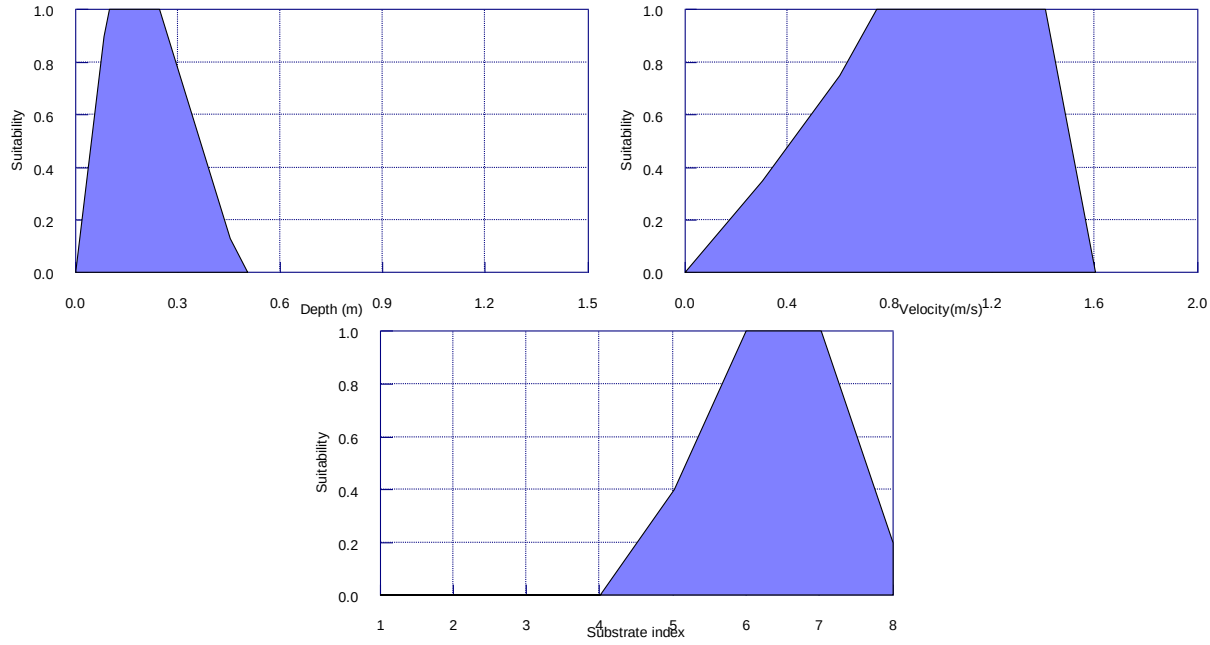
Food producing (Waters 1976)



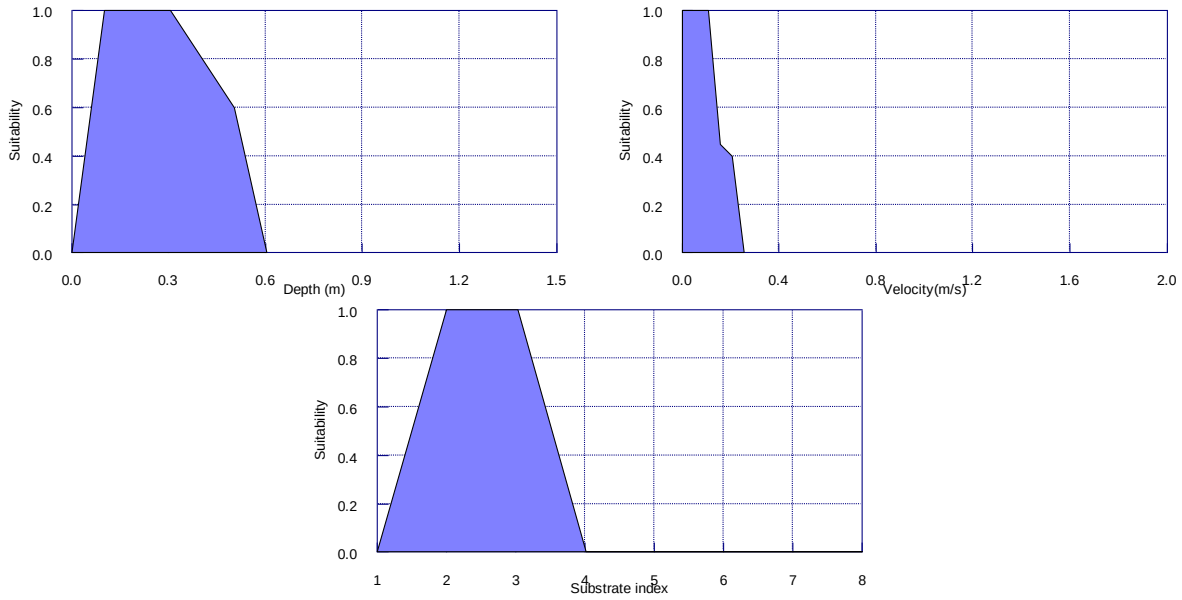
Deleatidium (mayfly)



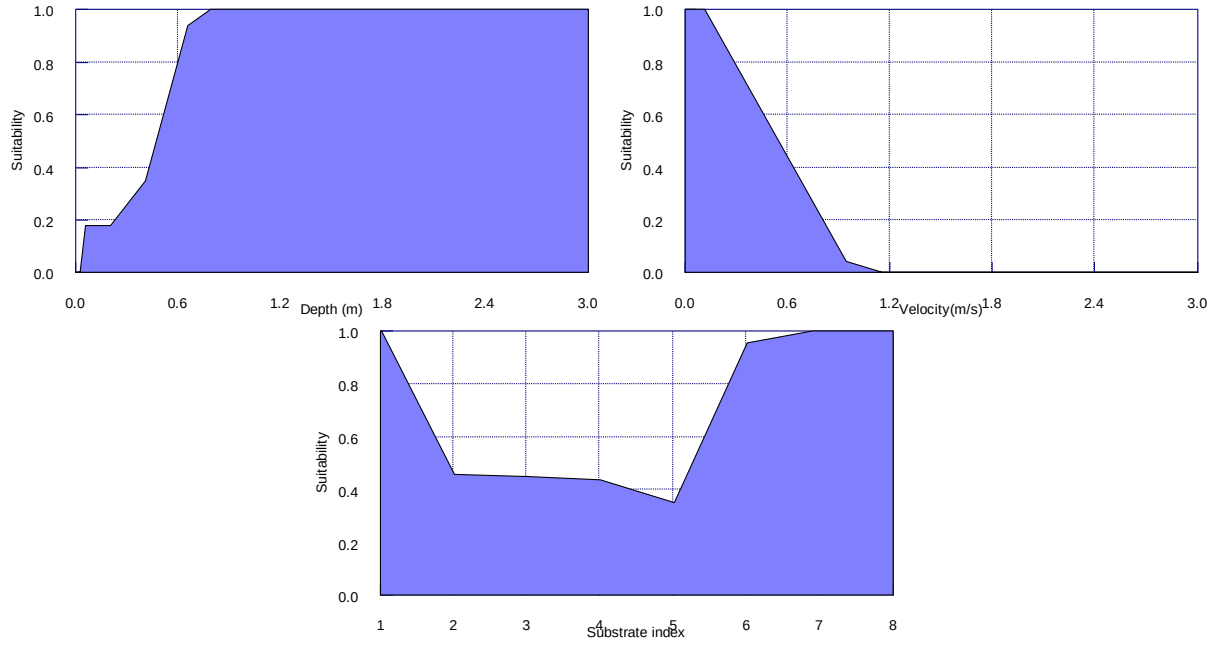
Koaro (Jowett & Richardson 2008)



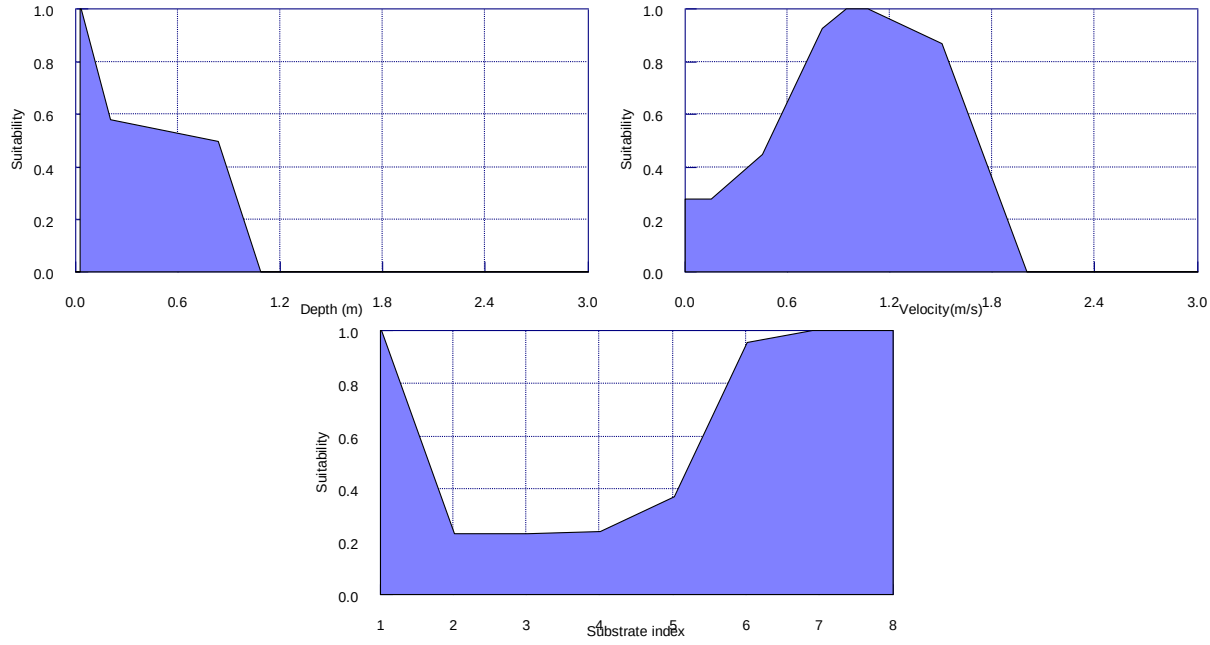
Lamprey (Jowett & Richardson 2008)



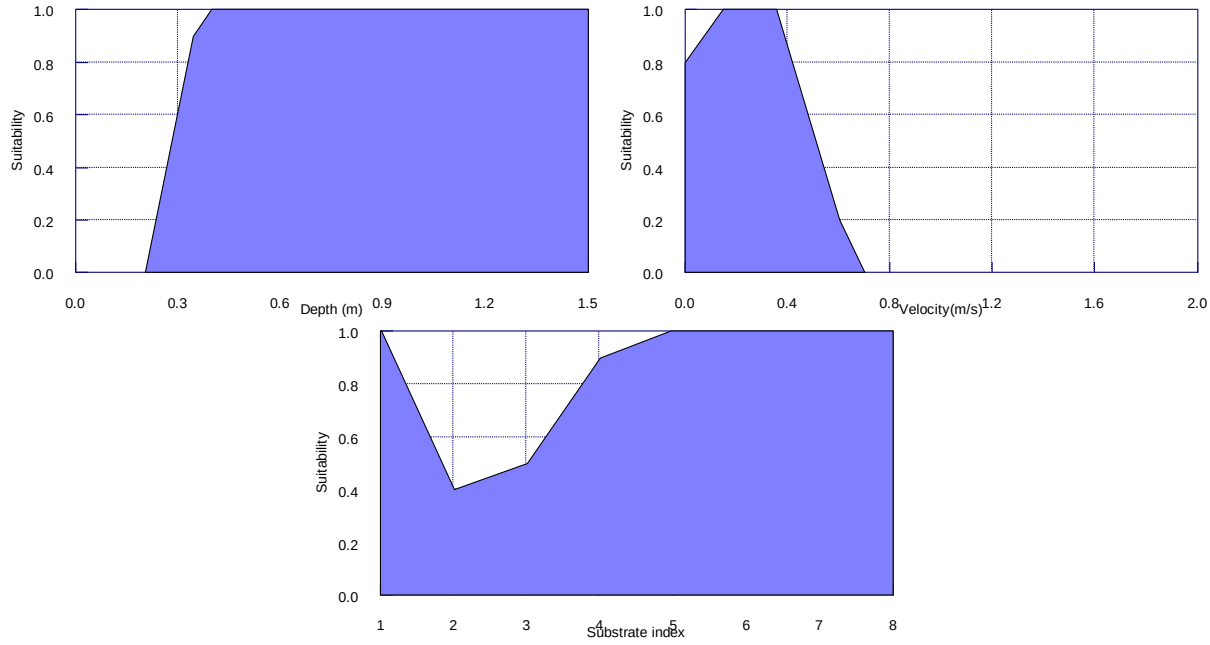
Longfin Eel > 300 mm (Jellyman)



Longfin Eel < 300 mm (Jellyman)



Longfin eel > 300mm (Jowett & Richardson 2008)



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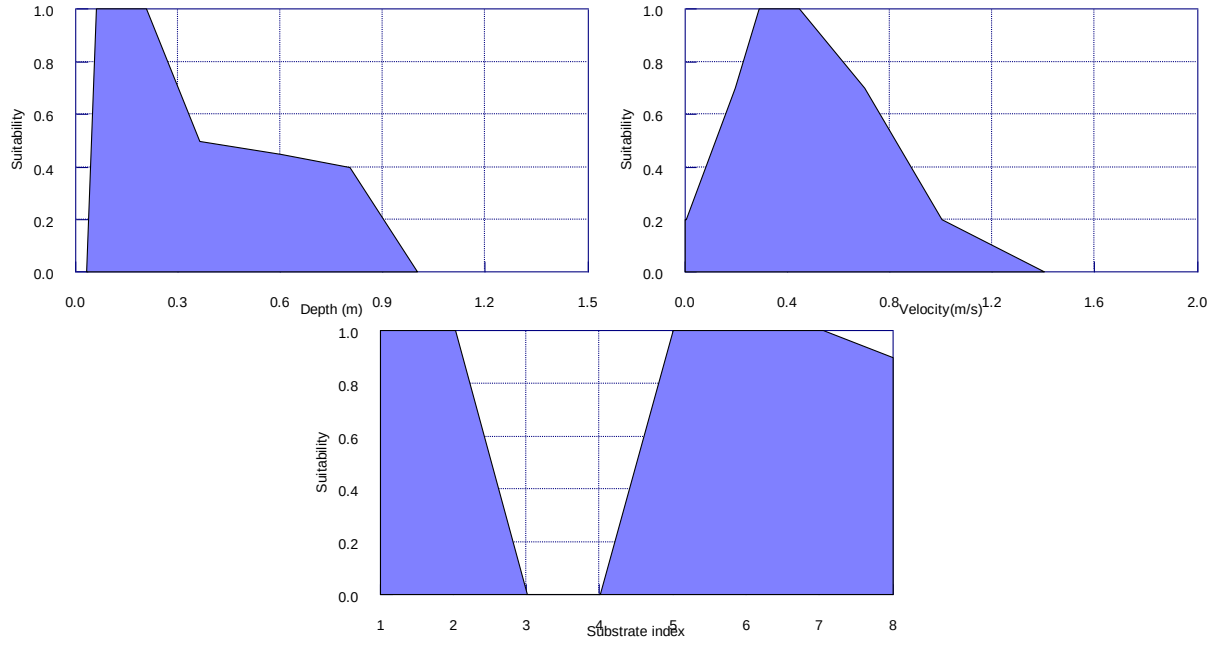
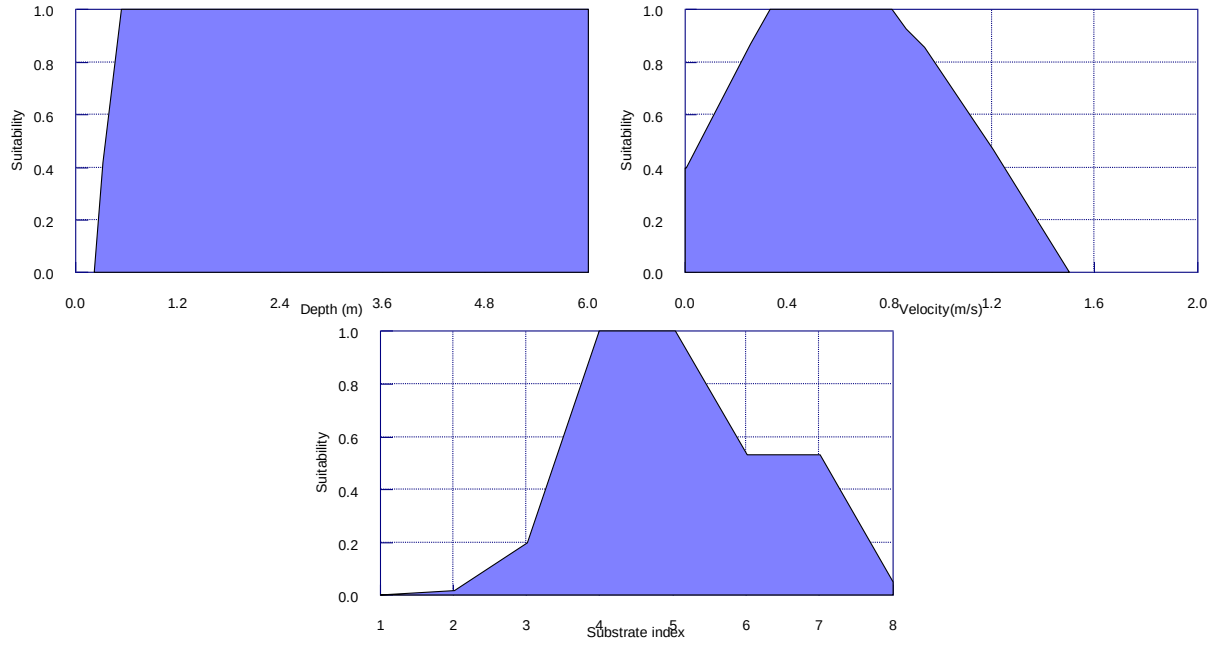
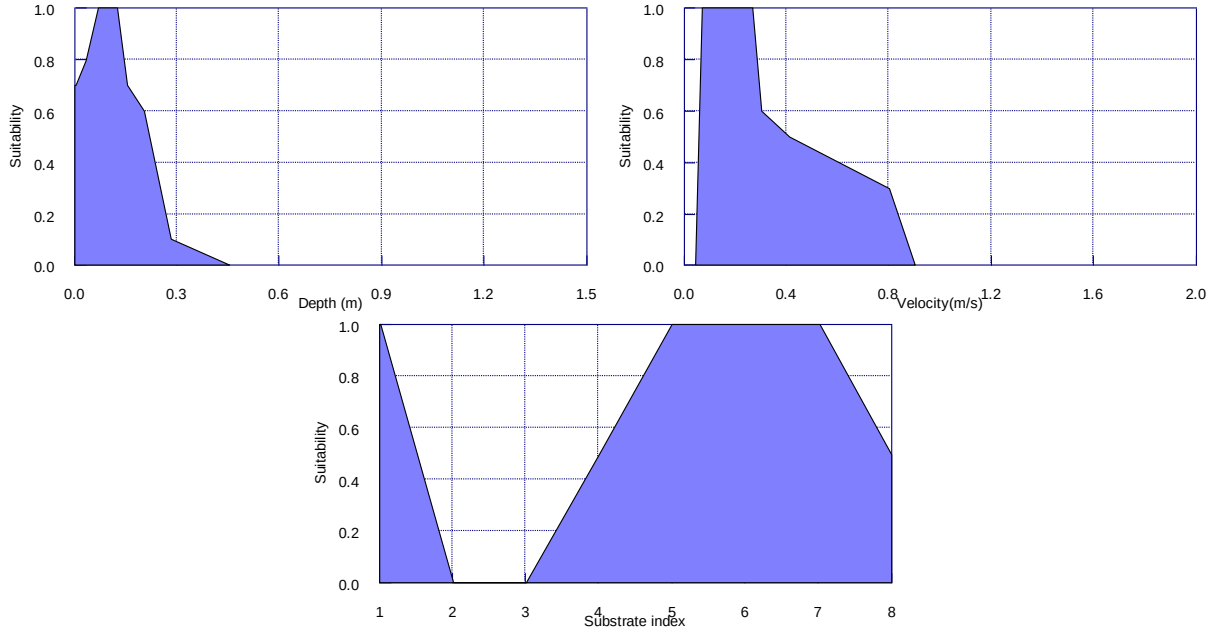


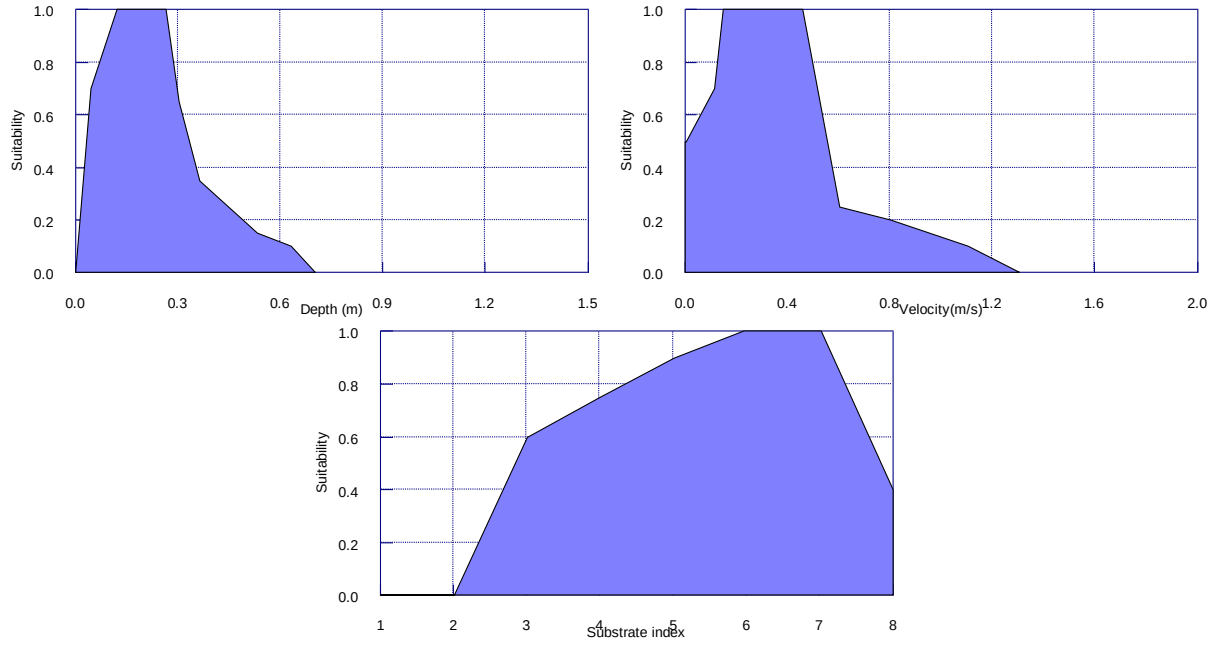
Rainbow trout (> 20cm) (Hawkes Bay Provisional)



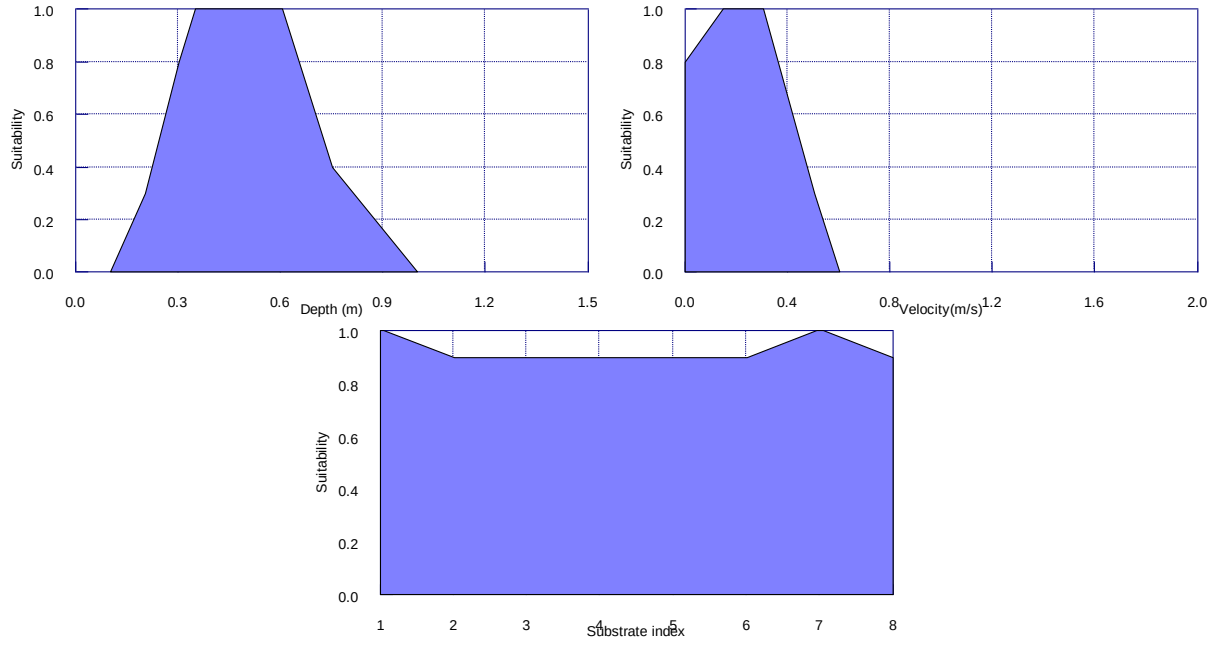
Rainbow trout (< 100 mm) (Jowett & Richardson 2008)



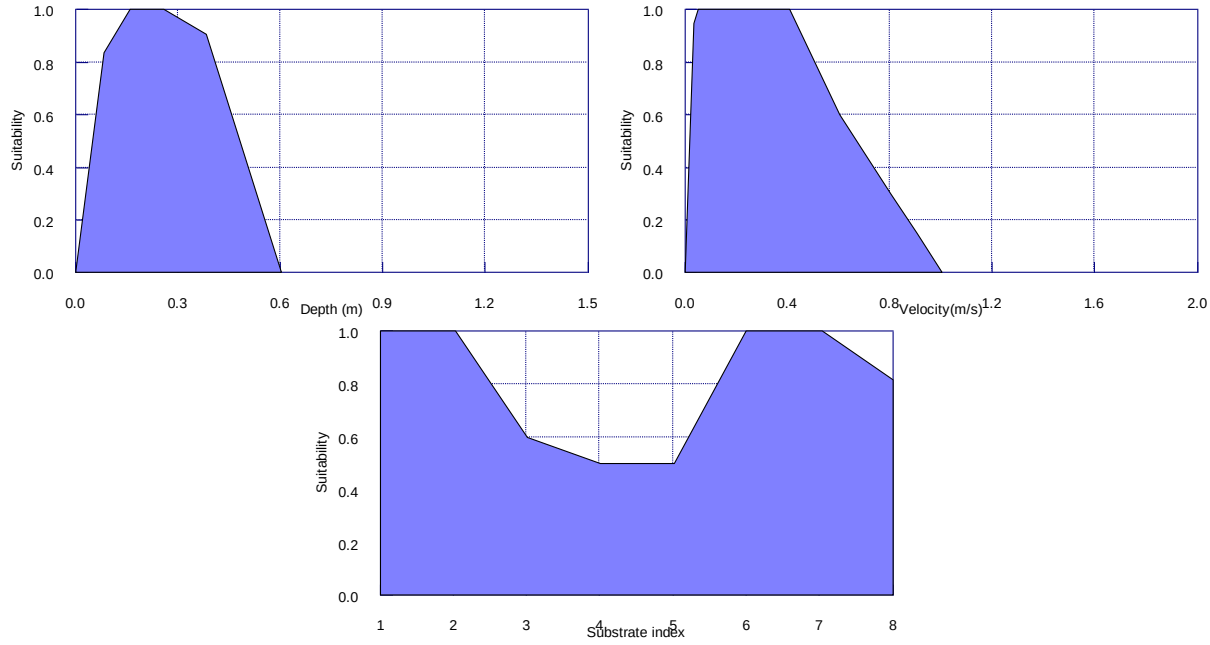
Redfin bully (Jowett & Richardson 2008)



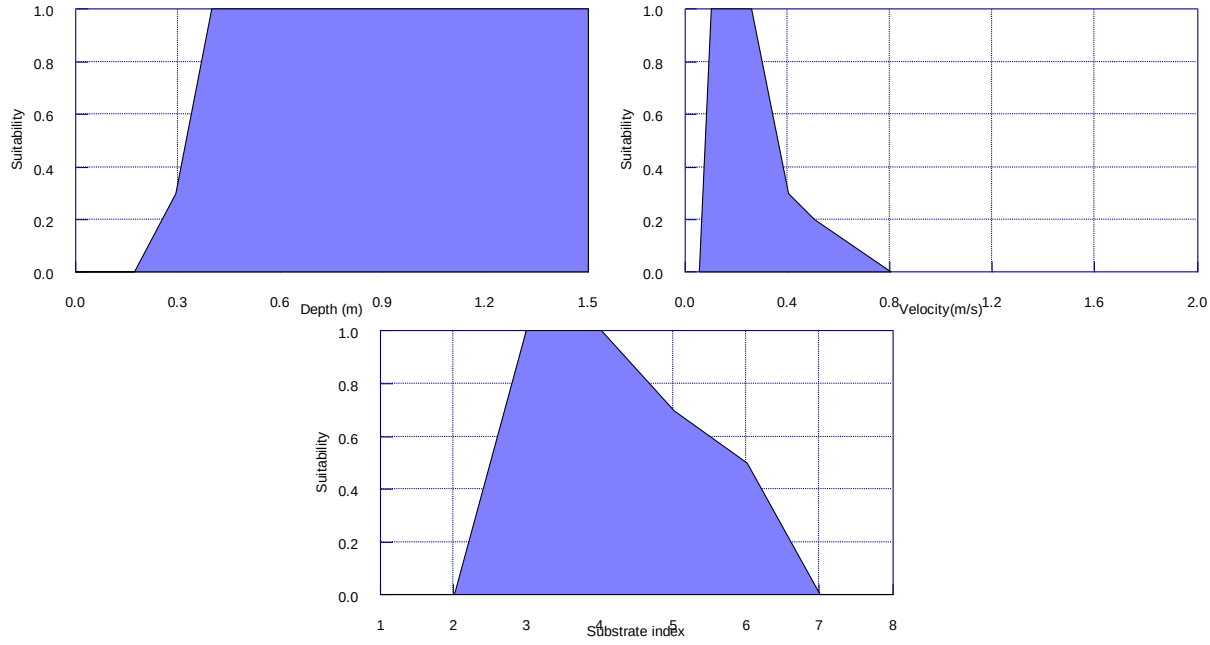
Shortfin eel > 300mm (Jowett & Richardson 2008)



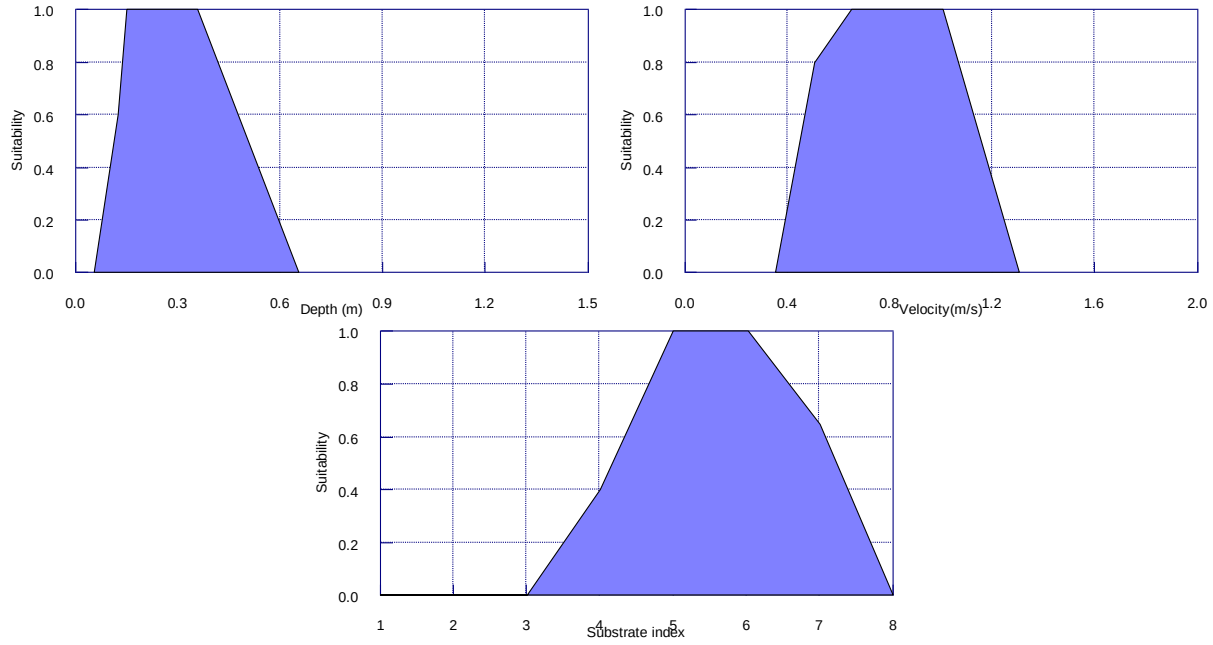
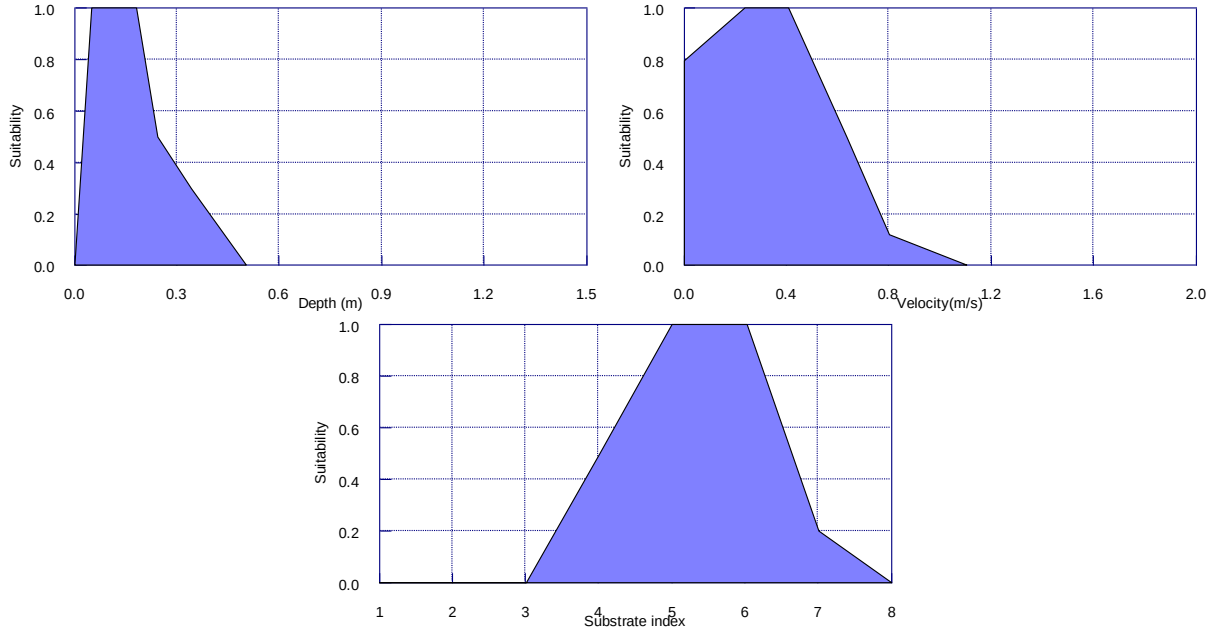
Shortfin eel < 300mm (Jowett & Richardson 2008)



Smelt (Jowett & Richardson 2008)



Torrentfish (Jowett & Richardson 2008)



Upland bully (Jowett & Richardson 2008)