Identifying the degree of hydrological alteration for ecological flow assessment in Northland streams

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Contents

Tables

Figures

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Executive summary

Northland Regional Council (NRC) commissioned NIWA to provide advice regarding prioritisation of catchments for assessment of ecological flow and water allocation limits. The aim of this project was to undertake a preliminary regional assessment of the risk of deleterious effects on instream habitat and degree of hydrological alteration in Northland rivers. This would support prioritisation of catchments and selection of appropriate technical methods for ecological flow determination at a regional scale in a manner consistent with the Proposed National Environmental Standard on Ecological Flows and Water Levels.

The risk of deleterious effects on instream habitat is typically highest in low order streams close to the coast. This is because loss of physical habitat caused by reductions in flow is more likely in smaller streams. The highest degree of hydrological alteration primarily occurs in the region between Whangarei and Dargaville, with a further area in the vicinity of Kerikeri. Many of the reaches that are classified as being at high risk of deleterious effects on instream habitat are not currently classed as being subject to a high degree of hydrological alteration.

Several of the major surface water catchments (SWC) have exceptionally high levels of consented water abstraction, which makes the risk of impacts on instream values high. These catchments are a priority for robust assessment of ecological flow requirements.

Many of the SWCs with a high proportion of stream and river reaches at high risk of deleterious effects on instream ecology are, at present, subject to relatively low levels of hydrological alteration at a SWC scale. It may be appropriate in these circumstances to establish relatively high default protection levels for instream values, rather than undertaking detailed assessments.

Risk classifications are provided as an ArcGIS shapefile: NRC water allocation catchment prioritisation.shp

1 Introduction

1.1 Background

Northland Regional Council (NRC) commissioned NIWA to provide advice regarding prioritisation of catchments for assessment of ecological flow and water allocation limits. This work was carried out under an Envirolink Small Advice Grant (970-NLRC131) from the Ministry of Science and Innovation. It continues work started under a previous Envirolink Small Advice Grant (920-NLRC126) providing advice on methods for ecological flow and water allocation assessment in Northland (Franklin 2010).

1.2 Scope

The aim of this project was to undertake a preliminary regional assessment of the risk of deleterious effects on instream habitat and degree of hydrological alteration in Northland rivers in accordance with the Proposed National Environmental Standard on Ecological Flows and Water Levels (NES) protocols (Beca 2008; MfE 2008). The assessment was to be at a regional scale and based on existing data including predicted probabilities of occurrence for fish (Leathwick et al. 2008) and the River Environment Classification (REC) (Snelder et al. 2004). This would support prioritisation of catchments and selection of appropriate technical methods for ecological flow determination at a regional scale in a manner consistent with the proposed NES.

This assessment was carried out in three stages:

1. Existing national GIS datasets were utilised to estimate the potential risk of deleterious effects on instream habitat according to predicted fish species presence and predicted mean stream flow (cf. Table 2.2 in Beca (2008)) at a regional scale.

2. Existing national GIS datasets were utilised to evaluate the baseflow status of rivers in the region.

3. Catchment scale estimates of total allocation provided by NRC were combined with 1 and 2 from above to evaluate the potential degree of hydrological alteration within the Northland region (cf. Table 2.3 in Beca (Beca 2008)).

1.3 Rationale

NRC is developing a sustainable water allocation regime. NRC has insufficient data on the ecological values of rivers to prioritise catchments and resources for water allocation assessment. A regional scale assessment utilising existing national datasets was proposed by NIWA to help inform decisions to prioritise catchments for assessment and provide guidance on appropriate technical methods (Franklin 2010). The approach taken was designed to be compatible with the guidance set out in the proposed NES (MfE 2008) and Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels (Beca 2008).

Beca (2008) proposes a risk based approach to evaluating the relationship between potential abstraction and the effects on instream management objectives or values. These risks are currently best understood for physical habitat for fish and are related to stream size and

preferred habitat preferences of the species present. Knowledge of fish communities and river size can therefore be used to make an assessment of the risk of deleterious effects on instream physical habitat. Knowledge of the potential risk of deleterious effects can be used to help identify priority areas for ecological flow assessment or protection.

The actual degree of impact will depend on the degree of hydrological alteration, whether the risk of deleterious effects is high or low. The extent to which abstraction increases the duration of low flows is considered a useful measure of the degree of hydrological alteration. A high degree of hydrological alteration is considered to occur when abstraction increases the duration of low flows (as defined by the 7-day mean annual low flow ($MALF^7$)) to about 30 days or more (Beca 2008). The risk of this occurring is dependent on flow regime, with low baseflow streams at higher risk than high baseflow streams.

Beca (2008) sets out how the risk of deleterious effects on instream habitat, proportion of baseflow, and magnitude of abstraction relative to mean annual low flows, combine to determine the degree of hydrological alteration. The higher the degree of hydrological alteration, the higher the potential risk to instream management objectives and values. It is a combination of this risk and the significance of instream values, which is used to determine the most appropriate methods to be used in the assessment of ecological flow requirements.

2 Methodology

2.1 Estimating potential risk of deleterious effects on instream habitat

The assessment of the risk of deleterious effects on instream habitat is based on the fish species present and natural mean stream flow (Table 2-1).

Table 2-1: Risk of deleterious effects on instream habitat for various fish species and natural mean flow. Adapted for Northland fish species from Table 2.2 in Beca (2008).

Mean flow ($m^3 s^{-1}$)	Inanga, banded kokopu & Cran's bully	Common bully, redfin bully	Torrentfish & salmonid spawning & rearing	Adult salmonids
<0.25	HIGH	HIGH	HIGH	HIGH
<0.75	MODERATE	HIGH	HIGH	HIGH
<5	LOW	MODERATE	HIGH	HIGH
<15	LOW	LOW	MODERATE	HIGH
15-20	LOW	LOW	LOW	MODERATE
>20	LOW	LOW	LOW	LOW

Less than 5% of New Zealand's rivers and streams have been surveyed for fish (Leathwick et al. 2008) and thus knowledge of fish communities occurring in the majority of rivers and streams is lacking. Leathwick et al. (2008) have developed statistical models to relate the probability of capture for different fish species to environmental conditions. These models have then been used to estimate the probability of capture for each fish species for rivers and streams throughout New Zealand, based on physical environmental conditions.

For the purposes of this study, this spatial database has been utilised to evaluate the likely occurrence of indicator fish species for all streams and rivers in Northland. An arbitrary threshold probability of occurrence of 0.75, equivalent to a 75% chance of a species being captured, was selected to identify the stream and river reaches where a species was considered likely to be present. ArcGIS was used to select each river reach where any of the species from each of the four risk groups identified in Table 2-1 had a probability of occurrence of ≥0.75. Figure 2-1 illustrates, based on these criteria, the predicted distribution of banded kokopu in Northland.

Mean flow is one of the physical environmental parameters used to derive the predicted probabilities of capture for the different fish species. ArcGIS was used to combine the mean flow variable with the predicted fish distributions to map the classifications of risk in Table 2-1 for deleterious effects on instream habitat.

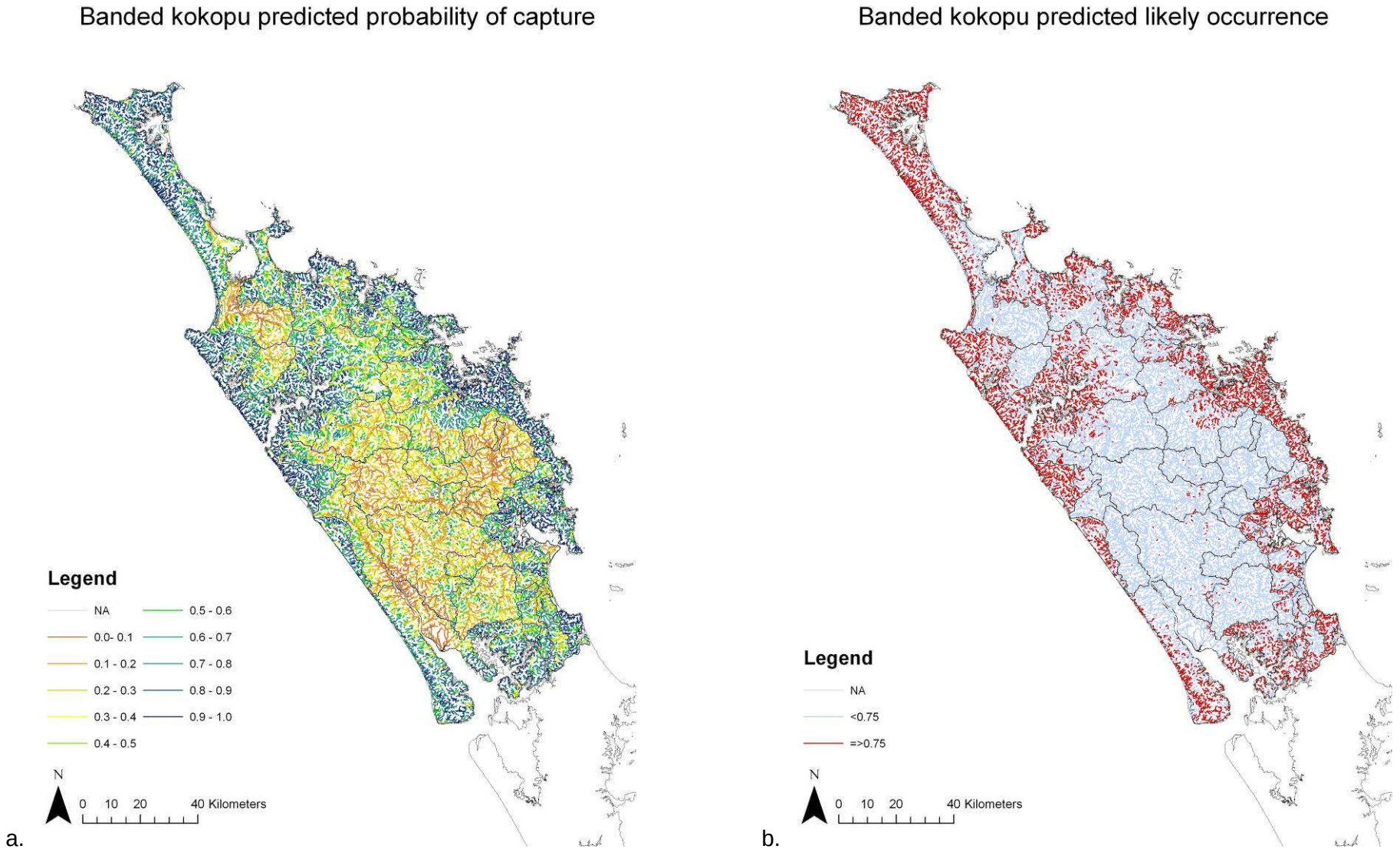

Figure 2-1: Predicted occurrence of banded kokopu in Northland rivers and streams. a. Predicted probability of capture for banded kokopu; and b. Predicted banded kokopu distribution used for this assessment.

2.2 Estimating potential degree of hydrological alteration

The assessment of the degree of hydrological alteration is based on the various risk classifications of stream size and fish species composition (Table 2-1), proportion of baseflow and the magnitude of abstraction relative to 7-day mean annual low flow ($MALF^7$) (Table 2-2).

Table 2-2: Relationship between degree of hydrological alteration and total abstraction expressed as % of $MALF^7$ for various risk classifications based on stream size and fish species composition. From Beca (2008).

Risk of deleterious effect						Degree of hydrological alteration
Low risk & high baseflow	Low risk & low baseflow	Moderate risk & high baseflow	Moderate risk & low baseflow	High risk & high baseflow	High risk & low baseflow	
<20%	<15%	<15%	<10%	<15%	<10%	LOW
20-40%	15-30%	15-30%	10-25%	15-30%	10-20%	MEDIUM
>40%	>30%	>30%	>25%	>30%	>20%	HIGH

This process involves three stages:

1. Determination of the ratio between mean flow and $MALF^7$.
2. Evaluation of total abstraction as a proportion of $MALF^7$.
3. Derivation of degree of hydrological alteration.

2.2.1 Determination of the ratio between mean flow and $MALF^7$

The ratio of mean flow to $MALF^7$ was calculated in ArcGIS using the modelled values for these parameters based on the REC network. Stream and river reaches were then classified as either high or low baseflow based on the criteria set out in Beca (2008):

High baseflow: (mean flow x $MALF^7$) < 20

Low baseflow: (mean flow x $MALF^7$) ≥ 20

2.2.2 Evaluation of total abstraction as a proportion of $MALF^7$

Total consented abstraction (at 18/05/2011) was calculated for each surface water catchment (SWC) by NRC. For each SWC where a long term flow record existed, NRC calculated $MALF^7$ for the most downstream point in the catchment. Where long term flow records were not available, the 1-day mean annual low flow ($MALF^1$) was estimated by a variety of methods. These estimates of $MALF^1$ were used as a surrogate for $MALF^7$ in this analysis. Total abstraction as a percentage of MALF was then derived for the most downstream point for each SWC.

The use of $MALF^1$ for some SWCs will lead to a slight overestimation of the proportion of low flows that is currently allocated. However, for a generalised regional assessment, this is not considered to be of concern and can be considered as a precautionary approach.

2.2.3 Derivation of degree of hydrological alteration

The criteria in Table 2-2 were used to classify stream and river reaches in Northland according to the degree of hydrological alteration. This was achieved by combining the risk of deleterious effects and baseflow classifications with the NRC estimates of allocation at the scale of SWCs using ArcGIS.

It was assumed for this analysis that the percentage allocation at the most downstream point of each SWC was representative of the level of allocation throughout the catchment. For a regional scale assessment, it was not deemed necessary to use spatially explicit, reach scale allocation totals.

3 Results

The risk of deleterious effects on instream habitat is typically highest in low order streams close to the coast (Figure 3-1). The majority of larger rivers in the region are classed as being at low risk. This is because physical habitat in large rivers is less susceptible to reductions in flow and because salmonid species, which tend to be the main indicator species in larger rivers, are relatively rare in Northland. Of the non-coastal SWCs, the lower Mangakahia SWC has the greatest proportion of high risk reaches.

The highest existing abstraction levels, relative to MALF, occur in the Wairoa (911%), Waipapa (757%) and Ruakaka (475%). There are a further ten catchments where existing consented abstraction is >40% of MALF (Figure 3-2).

The classification of hydrological alteration largely maps the relative levels of abstraction at a regional scale (Figure 3-3). The highest degree of hydrological alteration primarily occurs in the region between Whangarei and Dargaville, with a further area in the vicinity of Kerikeri. It is noted that many of the reaches that were classified as being at high risk of deleterious effects on instream habitat are not currently classed as being subject to a high degree of hydrological alteration.

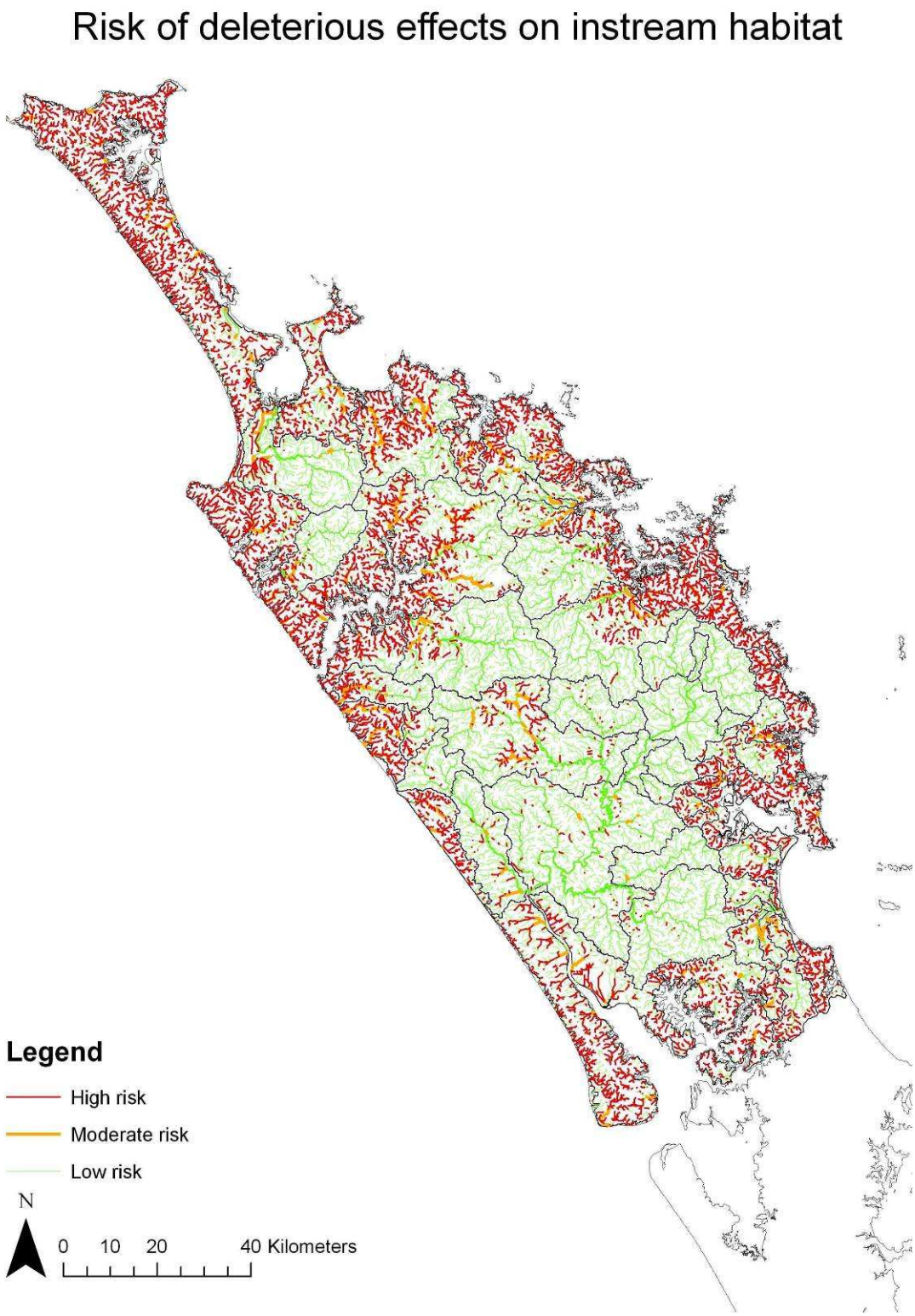

Figure 3-1: Potential risk of deleterious effects on instream habitat.

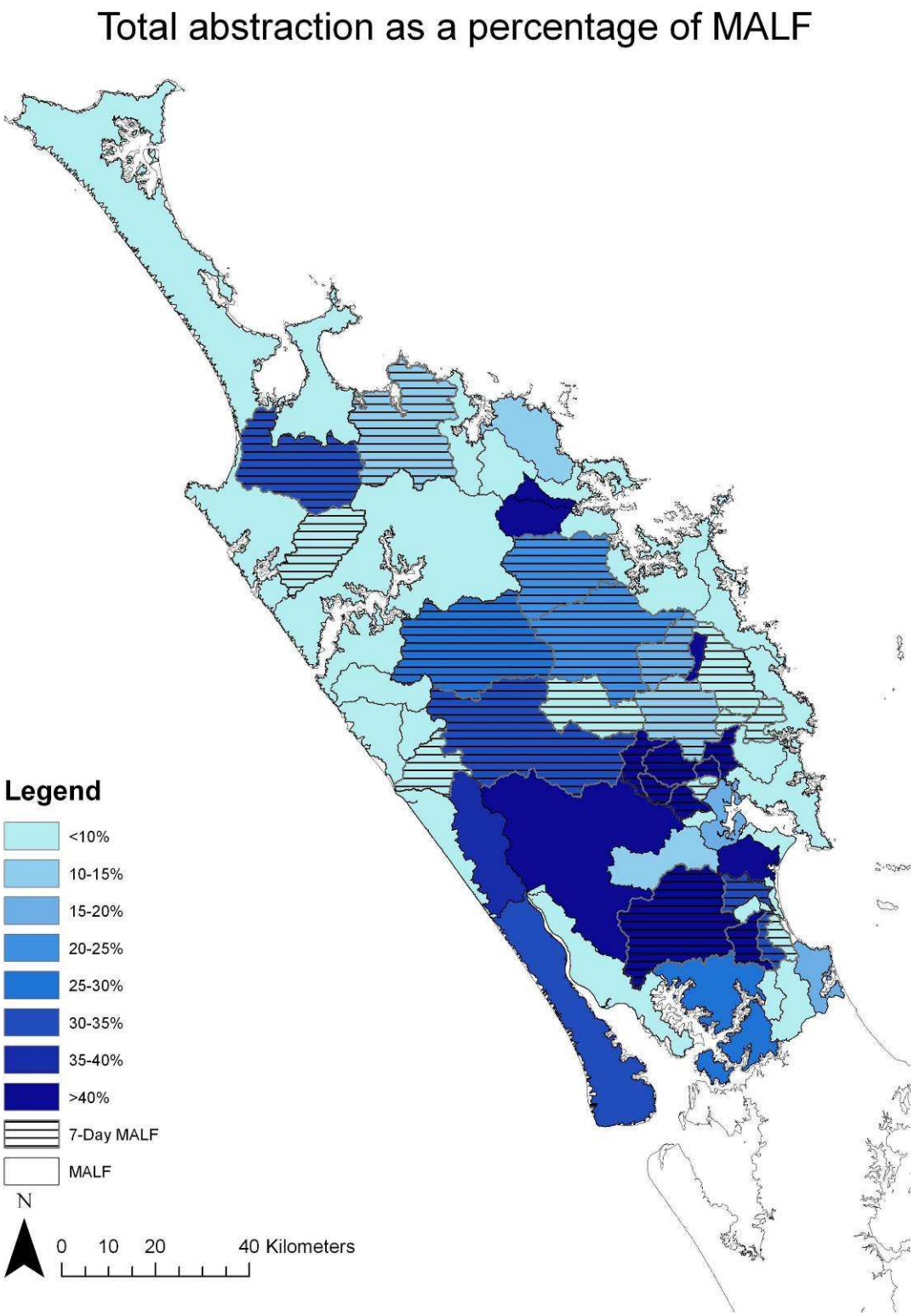

Figure 3-2: Total abstraction as a percentage of MALF. (Source: NRC).

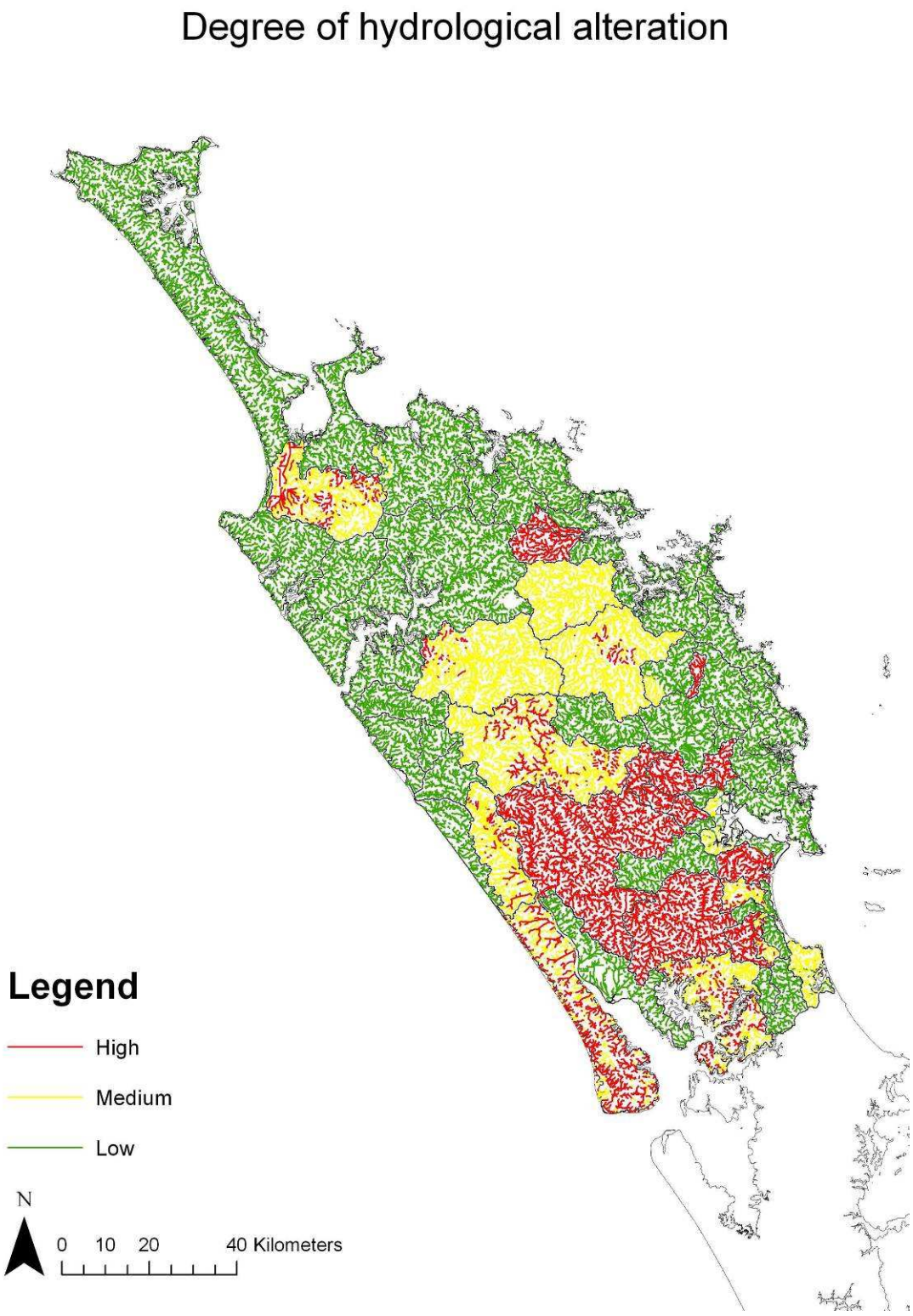

Figure 3-3: Potential degree of hydrological alteration.

4 Discussion

In order to establish a relationship between potential abstraction and the effects on instream values and management objectives, it is necessary to understand the risks involved. To support regional decision making processes and prioritisation of resources in Northland, this analysis has provided a regional risk assessment of the potential for deleterious effects on instream ecology and potential impacts of water abstraction.

Several of the major SWCs have exceptionally high levels of consented water abstraction relative to natural flows, which makes the risk of impacts on instream values high. These catchments are likely to be a priority for establishment of management objectives, detailed assessment of instream values and determination of robust ecological flow requirements.

Many of the SWCs with a high proportion of stream and river reaches at high risk of deleterious effects on instream ecology are, at present, subject to relatively low levels of hydrological alteration at a SWC scale. It may be appropriate in these circumstances where development pressures are low to establish relatively high default protection levels for instream values.

It should be noted that this assessment is only intended as a broad scale regional evaluation of potential risks, and that there will necessarily be local scale variations in pressures and risks that are not captured here, both within and between catchments. Whilst the outputs from this assessment can be used as a management tool for prioritisation of efforts and identification of appropriate assessment methods, they are not intended as a substitute for robust, catchment specific assessments of ecological flow requirements and water allocation limits. This is because we used data on estimated mean flow, MALF and likelihood of capture of fishes from national-scale databases. All three of these databases provide a good indication of broad-scale patterns. They each have their own associated uncertainties, and were not designed to provide site specific information.

5 Recommendations

5.1 Priority catchments

NRC need to establish a list of priority catchments based on the above results and local knowledge. A programme of ecological flow assessment for the Northland region should then be established. NIWA will provide advice and support on appropriate technical methods and their implementation.

5.2 Regional approaches to ecological flow determination

It is acknowledged that detailed ecological flow assessments are not appropriate for all catchments, but robust methods for establishing appropriate protection levels and allocation limits at a regional scale are necessary. NIWA is currently developing a suite of tools for assessing and defining environmental flow rules at a regional scale based on the REC, hydrologic data and generalised habitat modelling. NIWA will discuss with NRC the potential for using this methodology in Northland.

6 References

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Snelder, T.H.; Biggs, B.J.F.; Weatherhead, M. (2004). New Zealand River Environment Classification user guide. Wellington: Ministry for the Environment.