Riparian Management Classification Reference Manual

NIWA Client Report: HAM2009-072
June 2009

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Environment Canterbury

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1. Introduction

1.1 Riparian management

Stream management and restoration efforts in New Zealand often focus on management of riparian areas and typically involve excluding livestock and planting with native trees and shrubs (MFE 2001). The focus on riparian management is based on the contention that these land-water interface areas have a disproportionately large influence on stream habitat and water quality relative to their catchment area, owing to their proximity to the stream and their functions in reducing contaminant inputs from the broader landscape (DéCamps et al. 2004; Gregory et al. 1991; Naiman & Decamps 1997).

Riparian zones are defined as the areas where direct interaction between land and water occur (e.g., in terms of shading, inundation at normal high flows, input of wood and litter, provision of in-stream habitat as cover, use for spawning by stream biota) (Gregory et al. 1991; Naiman & Decamps 1997)(Fig. 1). Riparian management involves part or the entire riparian zone being managed differently to the adjacent land. This typically involves fencing to exclude livestock and allow a grass filter strip to develop and/or planting with native trees and shrubs in a **riparian buffer.**

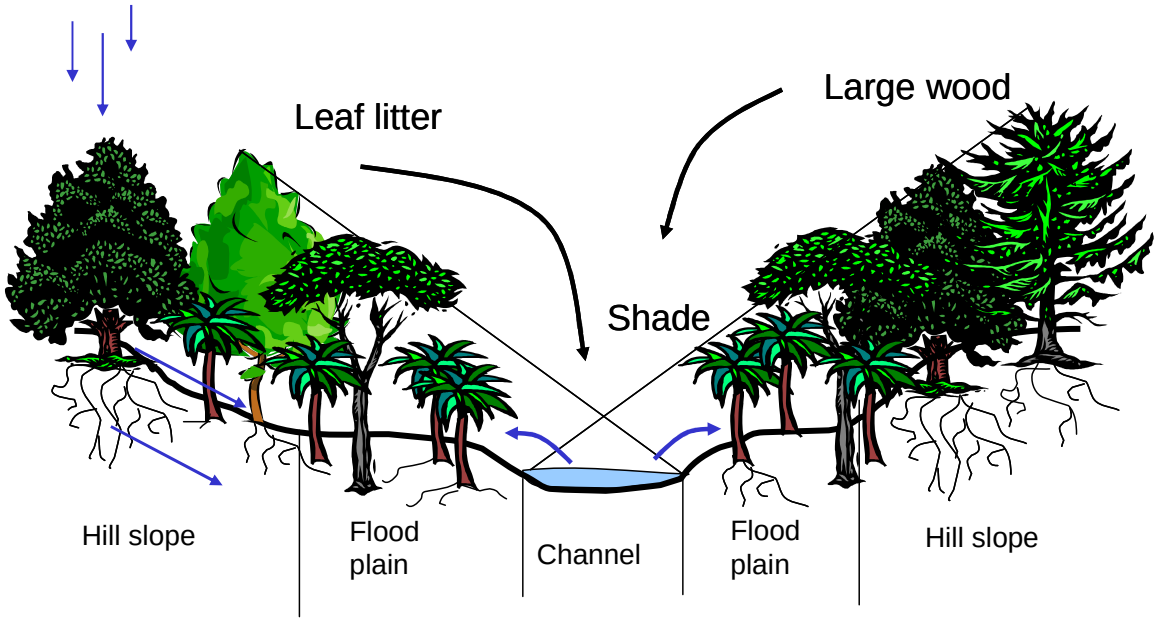


Figure 1: Schematic of a natural riparian zone showing influences on stream habitat. Blue arrows indicate movement of water and black arrows the input of resources.

The Riparian Management Classification (RMC) (Quinn 2003) provides a framework to guide catchment planning and management of the riparian margins to rehabilitate/restore stream health and functions that support ecosystem services. The RMC application involves rapid assessments of the current state of riparian zones and their current and potential functions in a study stream or catchment. These ***state*** assessments and ***function*** ratings provide information that can be used to prioritise and design riparian management within streams and catchments to enhance the return of investment of time and money. The method has been applied at scales ranging from catchments of varying sizes (Quinn & Bird 2007; Quinn et al. 2001) to the whole Canterbury region (Quinn 2003) and has supported deliberations and decisions on riparian management related to stream biodiversity enhancement and land use rezoning (Reeves 2004).

This manual is part of a project that aims to facilitate application of the RMC in Canterbury. It aims to support on-ground interpretation of the classification and development of a step-by-step process for rating, prioritising, and monitoring riparian management within a catchment. This manual is intended as a training and office reference document. A briefer companion manual (Quinn 2009b) is intended for field use.

This initial phase of the project involved a 2-day workshop with staff of Environment Canterbury in December 2008 to provide an introduction to the RMC method and gain staff input on information needs by applying riparian function assessment to the Cam River catchment. Findings for the Cam are summarised in Quinn (2009a).

1.2 Context for RMC application

RMC can inform waterway management by summarising: (i) how the ***current*** riparian management at stream and river sites contributes to waterway health; and (ii) the ***potential*** for improving this contribution by applying either ***pragmatic steps*** (that the land manager is likely to adopt and maintain with a modest level of support from the regional council) or ***best practice*** riparian management.

Examples of ***pragmatic steps*** are: (i) on a dairy farm, application of the minimum practices of livestock exclusion from waterways in the "Dairying and Clean Streams Accord"; (ii) on a drystock farm, establishing riparian trees in protective sleeves (to enhance streambank stability and shade in summer) and managing grazing to exclude/reduce riparian assess of cattle, but not sheep (e.g., with a single wire electric fence). Other compromises might allow for access to one side of the stream for drainage maintenance or maintaining areas of low stature vegetation to enhance angling opportunities along streams valued for trout fishing. Establishing which

pragmatic steps are taken is will likely involve dialogue with the land manager and may be an iterative process that is revisited in light of predicted costs vs. instream benefits. ***Best practice*** riparian management typically involves fencing the riparian area and stream and establishing a buffer of appropriate native vegetation. ECan's (2005) guidelines for managing water ways on farms provide advice on best practice designs for the main land forms found in the Canterbury region. Comparing the function rating gains between pragmatic and best practice riparian management will help inform the decision making process.

Figure 2 is a schematic of how RMC can fit within broader prioritisation and planning of efforts to meet catchment goals for stream and river ecosystems (e.g., by developing and implementing catchment and farm management plans).

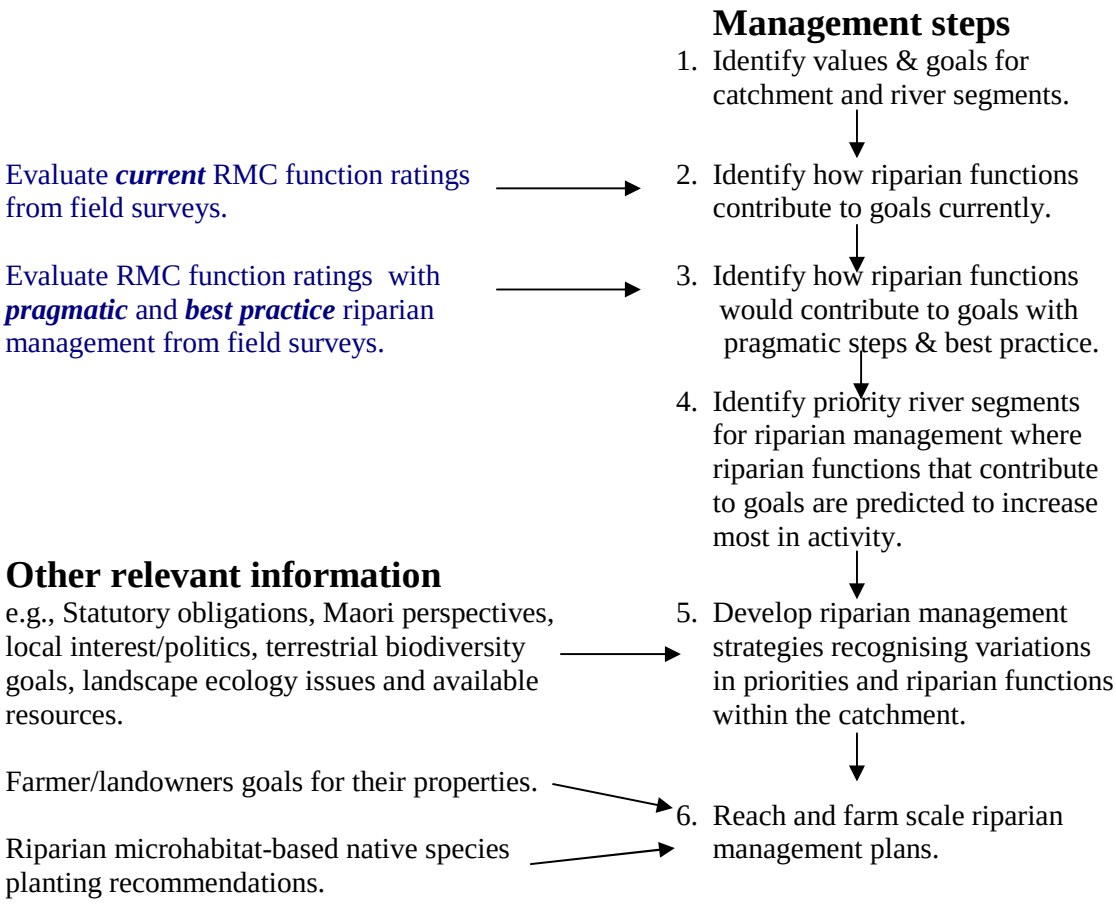


Figure 2: Flowchart showing how the RMC approach (steps in blue) can contribute to catchment planning.

RMC is most useful where waterway values and associated goals have been clearly defined, so that riparian management targets specific locations and designs that improve riparian functions directly linked to these goals. For example, if a key goal is to control nuisance phytoplankton blooms in a downstream lake (related to the catchment nutrient load), then the RMC can be used to identify sites where ratings of

nutrient retention functions (denitrification of shallow groundwater, uptake of nutrients from shallow groundwater and filtering of surface runoff) are currently or potentially high. Sites with current high nutrient retention function ratings could then be targeted for **protection,** while sites where differences between current and potential ratings are high would be obvious places to focus riparian **enhancement** so that the potential gains are realised.

The RMC ratings from a catchment study also provide useful summary information on the general contribution of riparian management to stream condition and opportunities for enhancement. For example, the RMC surveys of sites in the Ohariu catchment (Quinn & Bird 2007) found that current ratings were greatest for bank stabilisation and least for enhancing recreation (Fig. 3). Application of best riparian practice would enhance several functions, but produce little improvement in denitrification (Fig. 3).

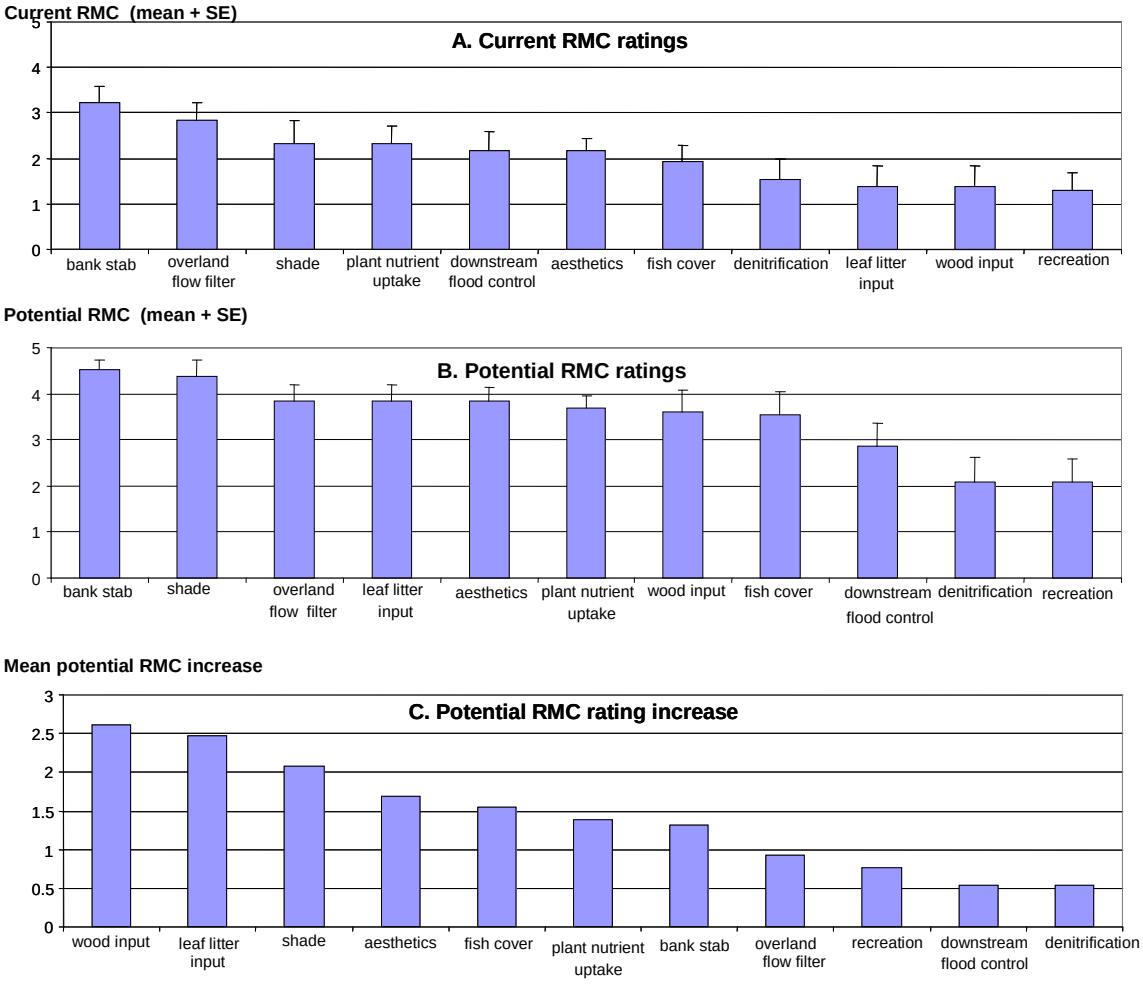


Figure 3: Average current and potential best practice ratings of riparian functions at 13 Ohariu Valley sites (Quinn and Bird 2007) as a way of summarising catchment-wide riparian functions.

The sum of the current and potential function ratings at sites in a catchment also provides a summary of where riparian management is likely to have the most overall benefit. For example, the Ohariu study identified site 5 (representative of upper catchment floodplains) as having the greatest potential for enhancement by riparian management (Fig. 4).

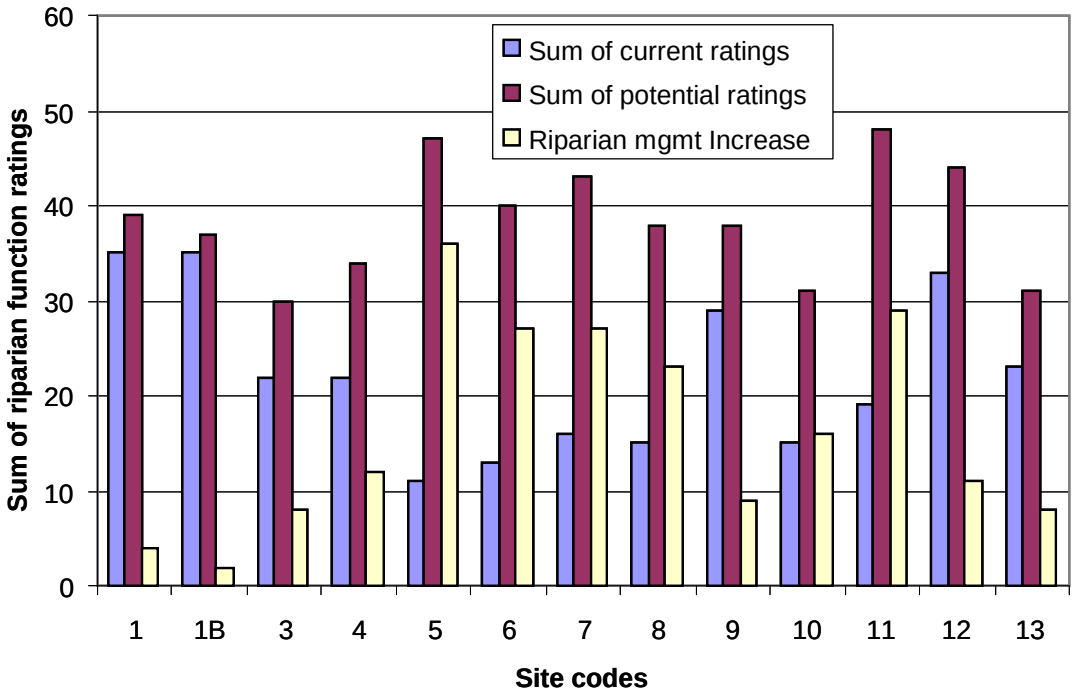


Figure 4: Sum of all ratings for riparian functions under current conditions and potential conditions if best riparian management practice was applied at Ohariu catchment sites. The difference between these sums of ratings (potential – current) represents the potential overall riparian management benefit. Note the potential benefit is greatest at site 5 and least at site 1B.

In the Cam, the differences in total RMC ratings between current and best practice conditions were less striking than in the Ohariu (Fig. 5B c.f. Fig. 4), but nevertheless indicate that applying best practice riparian management would achieve the greatest overall gains at Site 7 (Northbrook at Marshs) (Fig. 5).

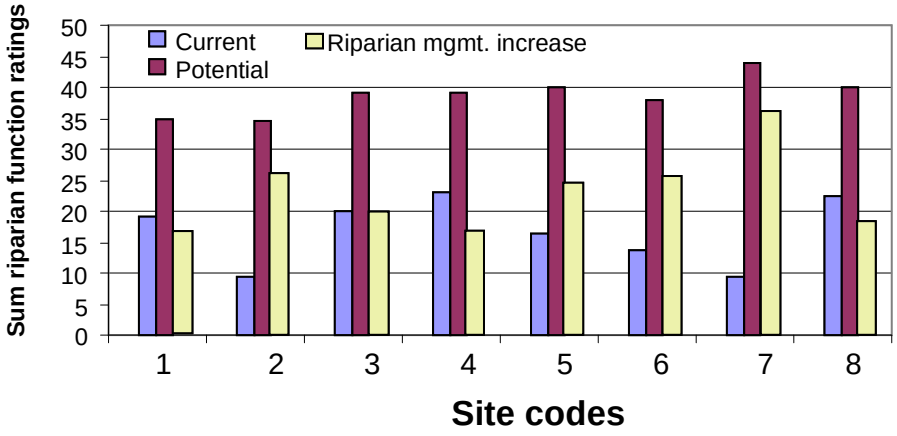


Figure 5: Sum of all ratings for riparian functions under current conditions and potential conditions if best riparian management practice was applied at Cam catchment sites. The difference between these sums of ratings (potential – current) represents the potential overall riparian management benefit. Note the potential benefit is greatest at site 5 and least at sites 1 and 4 (adapted from Quinn 2009).

1.3 Monitoring riparian functions

RMC has potential for use in State of the Environment (SOE) assessment as a measure of land use pressure management within catchments by repeat riparian function assessments over time. I recommend that this be linked to the riparian monitoring Protocol II in the Stream Habitat Assessment Protocols (Harding et al. 2009) that has been designed specifically for SOE monitoring.

2. RMC Methodology Overview

2.1 Introduction

This manual describes two aspects of the RMC: (1) assessment of the state of the riparian area and key attributes of the stream and surrounding land (Section 3); and (2) rating riparian functions under current conditions and future scenarios of pragmatic management and best riparian practice (Section 4). The function rating is the most important aspect of the RMC. The state assessment provides the context for the function ratings. **This may be substituted by other protocols,** such as the ECan Streamwalk methodology or Protocol 1 of the Stream Habitat Assessment Protocols (Harding et al. 2009), in which case section 3 of this manual can be skipped.

2.2 Planning the field survey

The scope of the field survey will vary with a project's aims, scale and the resources available. Each reach assessment takes approximately 30-40 minutes when the assessor is familiar with the method. If the focus is on an individual farm, it may be practicable to survey representative sections of all streams within a short period (e.g., ½-1 day or less). In larger catchments it may be necessary to survey a selection of reaches to determine variations in riparian state and functions. Sites can be selected at random (e.g., by randomly selecting reaches within the catchment from the River Environments Classification (REC) (Snelder et al. 2004)), stratified random (e.g., randomly selecting REC reaches within different geographic settings, environment classes (e.g., based on REC (Leathwick et al. 2008a) classes, land use classes/farm systems and/or stream orders), or biased to easy access points or parts of the catchment where there is known interest in riparian management or stream restoration. If survey reaches are selected based on stream order, then the number of survey reaches in each stream order should reflect stream length (i.e., survey reaches allocated to $1^{st} > 2^{nd} > 3^{rd} > 4^{th}$ order reaches). Random site selection methods are favoured, because they support the most robust generalisations about riparian function ratings within the study area, but these may not be practicable due to access or resource constraints.

If the aim of an investigation is to monitor temporal changes (e.g., in SOE monitoring), fewer sites will need to be selected, but each site will be visited on multiple occasions, perhaps over a considerable time period. In this case, it is important to ensure that sites can be found again, potentially after substantial changes have occurred in the surrounding landscape and assessment personnel. Recording accurate grid references, noting prominent structures nearby, and making site

diagrams will all aid in ensuring that same reach is re-sampled on subsequent occasions.

2.3 Survey reach dimensions

The length of the stream reach in each survey unit can be varied to match management units (e.g., farm paddocks) or areas of relatively uniform physical character. Reaches of 50-100 m length are usually practical for integrating representative information on site attributes and riparian functions on small streams. Reach lengths should increase with stream width up to say 300 m on wide rivers (channel > 50 m).

2.3.1 Field equipment

The minimum equipment requirements are a digital camera and survey sheets (ideally printed on water-proof paper). A map of the survey area is essential. A GPS is helpful for geo-referencing sites and a tape measure (or 1.5 m survey pole) is useful for quick checks on distance estimates and bank heights and stream widths.

Reference material for identification of macrophytes (e.g., laminated printouts of NIWA quick guides http://www.niwa.co.nz/our-science/aquatic-biodiversity-and-biosecurity/our-services/all/aquaticplants/outreach.) and native and exotic terrestrial plants (e.g., (Roy et al. 2004; Salmon 1986) are also useful to have in your vehicle.

3. Riparian State Assessment

3.1 Introduction

Figure 6 provides an example of a completed riparian state assessment form. The example site is the Northbrook and Marsh's Rd (see lower image in Figure 21c for a site photograph). The methodology below follows the order of the items in the riparian state assessment form. Note that the left and right sides of the stream are defined looking downstream (as is standard for hydrological assessments).

3.2 Calibration of visual assessments: "getting your eye in"

To enable rapid assessment, all information is gathered by visual inspection and qualitative estimation (c.f., quantitative measurement). However, surveyors should carry out sufficient quantitative measurements (e.g., using tape measures of attributes such as channel widths and inclinometers to measure hill slope angles) to provide confidence in their estimates.

3.3 Site Location

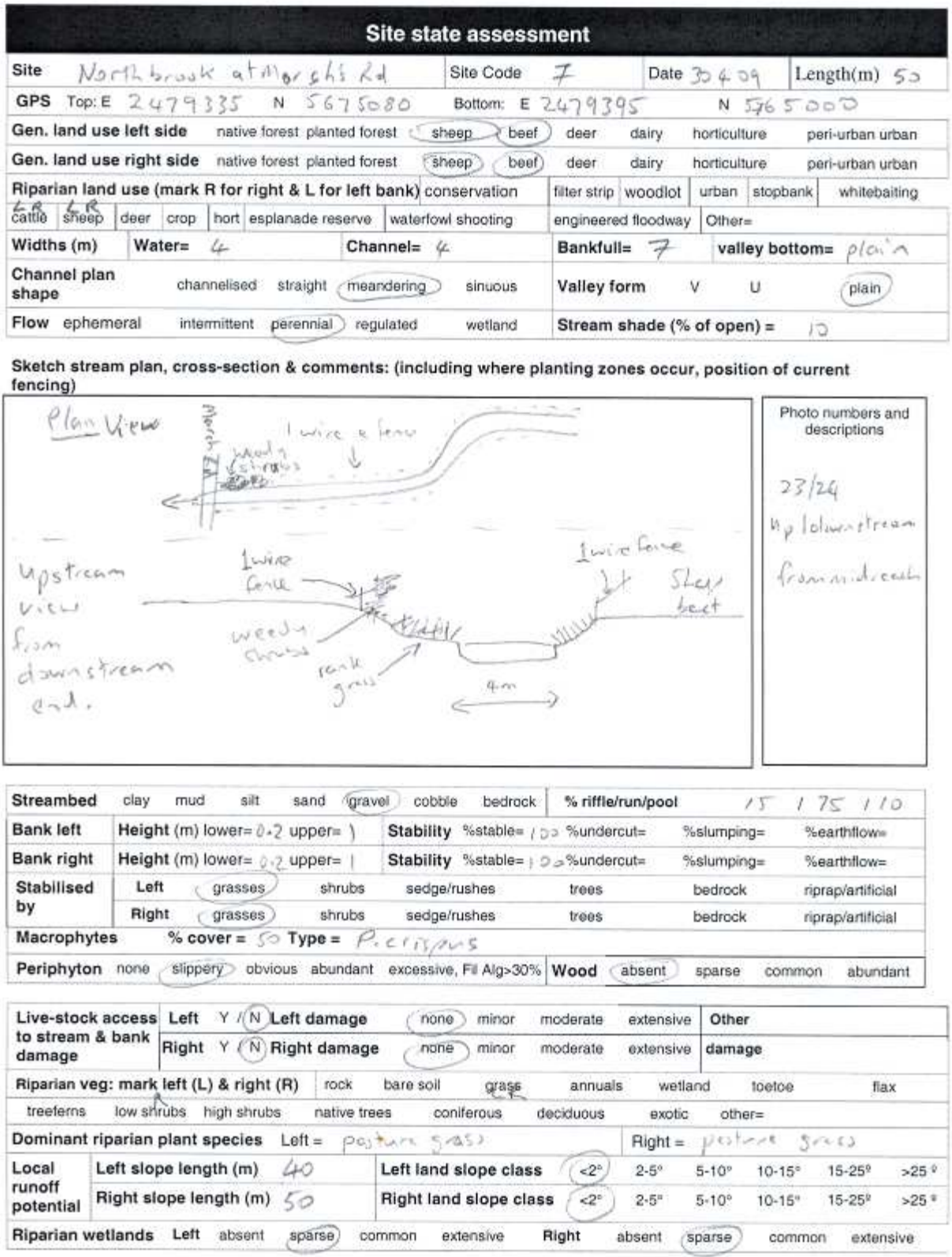
Information is needed to be able to relocate the site and link the data to a geo-reference (map or GIS location). Assign a unique site code and if possible record the GPS coordinates at the top and bottom of the survey reach.

3.4 General land use

General land use influences the local pressures on the riparian area and stream. Here we are interested in the use beyond the riparian area. Circle one or more of the land use classes as appropriate.

3.5 Riparian land use

This refers to the land use immediately adjacent to the stream that comprises an identifiable riparian zone (e.g., area with distinct riparian forest or wetland vegetation) or, if this is not identifiable, to 10-20 m from the edge of the stream channel. Use L or R to define riparian land uses on the left and right sides of the stream.



Site state assessment

Site	Northbrook at Marshs Rd	Site Code 7	Date 30 4 09	Length(m) 50
GPS	Top: E 2479335 N 5675080	Bottom: E 2479395	N 5765000	

Gen. land use left side	native forest	planted forest	(sheep)	(beef)	deer	dairy	horticulture	peri-urban urban
Gen. land use right side	native forest	planted forest	(sheep)	(beef)	deer	dairy	horticulture	peri-urban urban

Riparian land use (mark R for right & L for left bank)	conservation		filter strip	woodlot	urban	stopbank	whitebaiting			
LR cattle	LR sheep	deer	crop	hort	esplanade reserve	waterfowl shooting	engineered floodway	Other=		

Widths (m)	**Water=** 4	**Channel=** 4	**Bankfull=** 7 **valley bottom=** plain
Channel plan shape	channelised straight (meandering) sinuous	**Valley form** V U (plain)	
Flow ephemeral intermittent (perennial) regulated wetland	**Stream shade (% of open) =** 10		

Sketch stream plan, cross-section & comments: (including where planting zones occur, position of current fencing)

Photo numbers and descriptions

23/24
Up / downstream from mid creek

Streambed	clay	mud	silt	sand	(gravel)	cobble	bedrock	**% riffle/run/pool** 15 / 75 / 10
Bank left	**Height** (m) lower= 0.2 upper= 1				**Stability** %stable= 100	%undercut=	%slumping=	%earthflow=
Bank right	**Height** (m) lower= 0.2 upper= 1				**Stability** %stable= 100	%undercut=	%slumping=	%earthflow=
Stabilised by	**Left**	(grasses)	shrubs	sedge/rushes	trees	bedrock	riprap/artificial	
	Right	(grasses)	shrubs	sedge/rushes	trees	bedrock	riprap/artificial	
Macrophytes	**% cover =** 50 **Type =** P. crispus							
Periphyton	none	(slippery)	obvious	abundant	excessive, Fil Alg>30%	**Wood**	(absent)	sparse common abundant

Live-stock access to stream & bank damage	**Left** Y / (N)	**Left damage**	(none)	minor	moderate	extensive
	Right Y / (N)	**Right damage**	(none)	minor	moderate	extensive

Other damage

Riparian veg: mark left (L) & right (R)	rock	bare soil	grass	annuals	wetland	toetoe	flax
treeferns	low shrubs	high shrubs	native trees	coniferous	deciduous	exotic	other=

Dominant riparian plant species Left = pasture grass Right = pasture grass

Local runoff potential	**Left slope length (m)** 40	**Left land slope class**	(<2°)	2-5°	5-10°	10-15°	15-25°	>25°
	Right slope length (m) 50	**Right land slope class**	(<2°)	2-5°	5-10°	10-15°	15-25°	>25°

Riparian wetlands	**Left**	absent	(sparse)	common	extensive	**Right**	absent	(sparse)	common	extensive

Figure 6: An example of a completed RMC state assessment form.

3.6 Stream and valley widths

Stream width influences the effects of riparian vegetation on stream shade and input of leaf litter and wood to the channel. Channel and valley bottom width influence how riparian areas interact with high flows and affect local and downstream flooding.

Water width is the average wetted width of the stream at right angles to the flow (Fig. 7). **Channel width**, in this context, is the width of the channel between the terrestrially vegetated areas on the margins (Fig. 7). **Bankfull width** is that at which the stream would overtop its normal banks in high flows. **Valley bottom width** is the distance between the base of the hills on either side of the stream valley (Fig. 7). If the stream reach runs through extensive plains enter "plains".

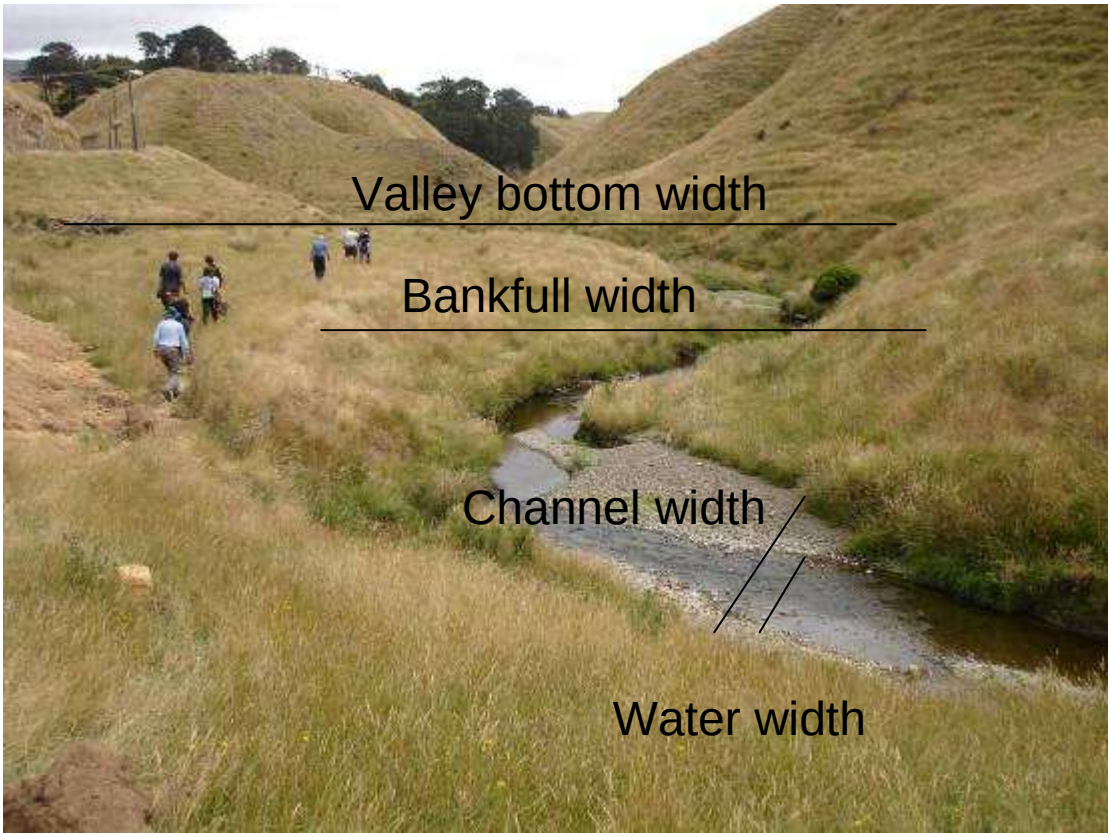


Figure 7: Examples of the different stream and valley widths measured in RMC state assessment.

3.7 Channel plan shape

Channel plan shape can influence how the riparian vegetation affects stream shading, habitat and downstream flows during high flow events. Schematic drawings of the 3 main categories; straight, meandering and sinuous as shown in Figure 8. As with all classifications there are intermediate stages that are best dealt with by circling the two classes that the situation bridges. Channelised streams are typically straight but artificially deepened/widened to enhance their drainage capacity.

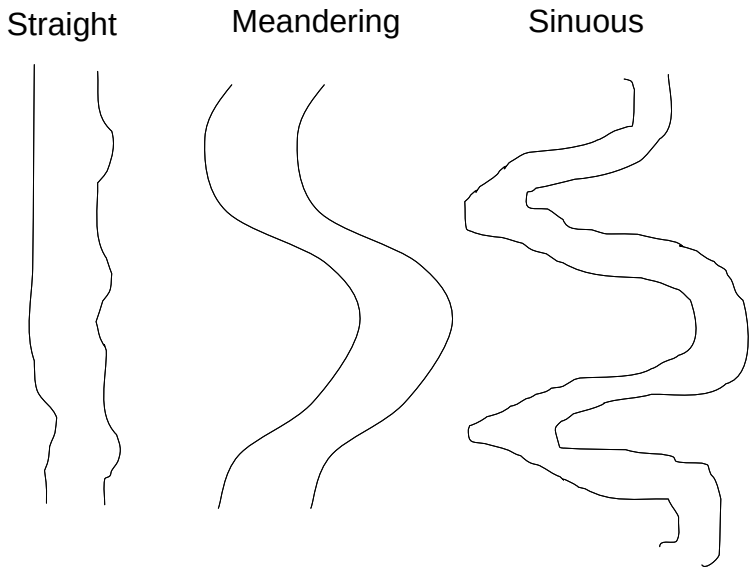


Figure 8: Representative channel plan forms in RMC state assessment.

3.8 Valley form

Valley form influences how the riparian area receives overland flow from the land and/or flood flows from the channel. ECan's (2005) riparian guidelines provide different recommendations for the three landform classes identified as V-shaped, U-shaped and plain, as illustrated in Figure 9 and photographs in Figure 10.

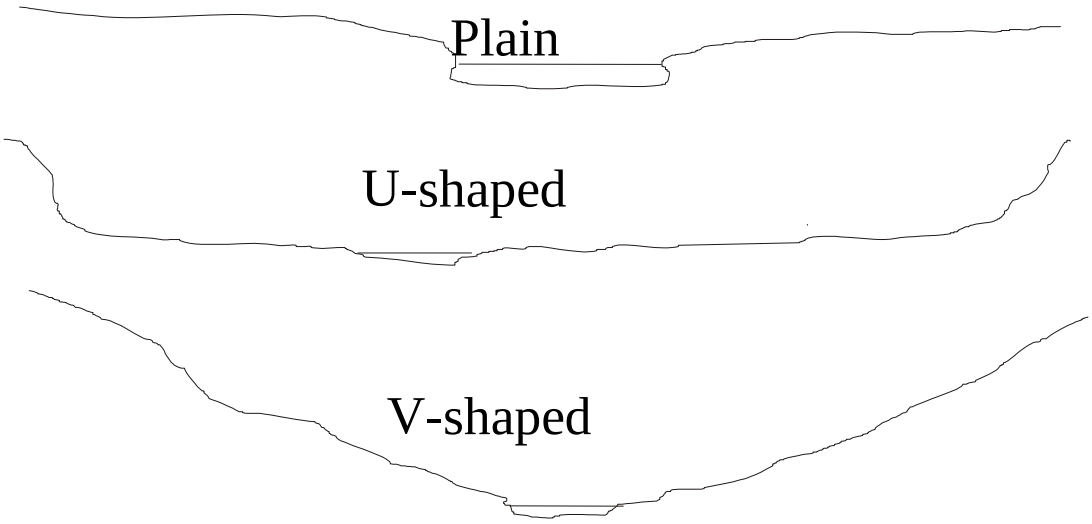


Figure 9: Schematic illustrations of valley forms in RMC state assessment.

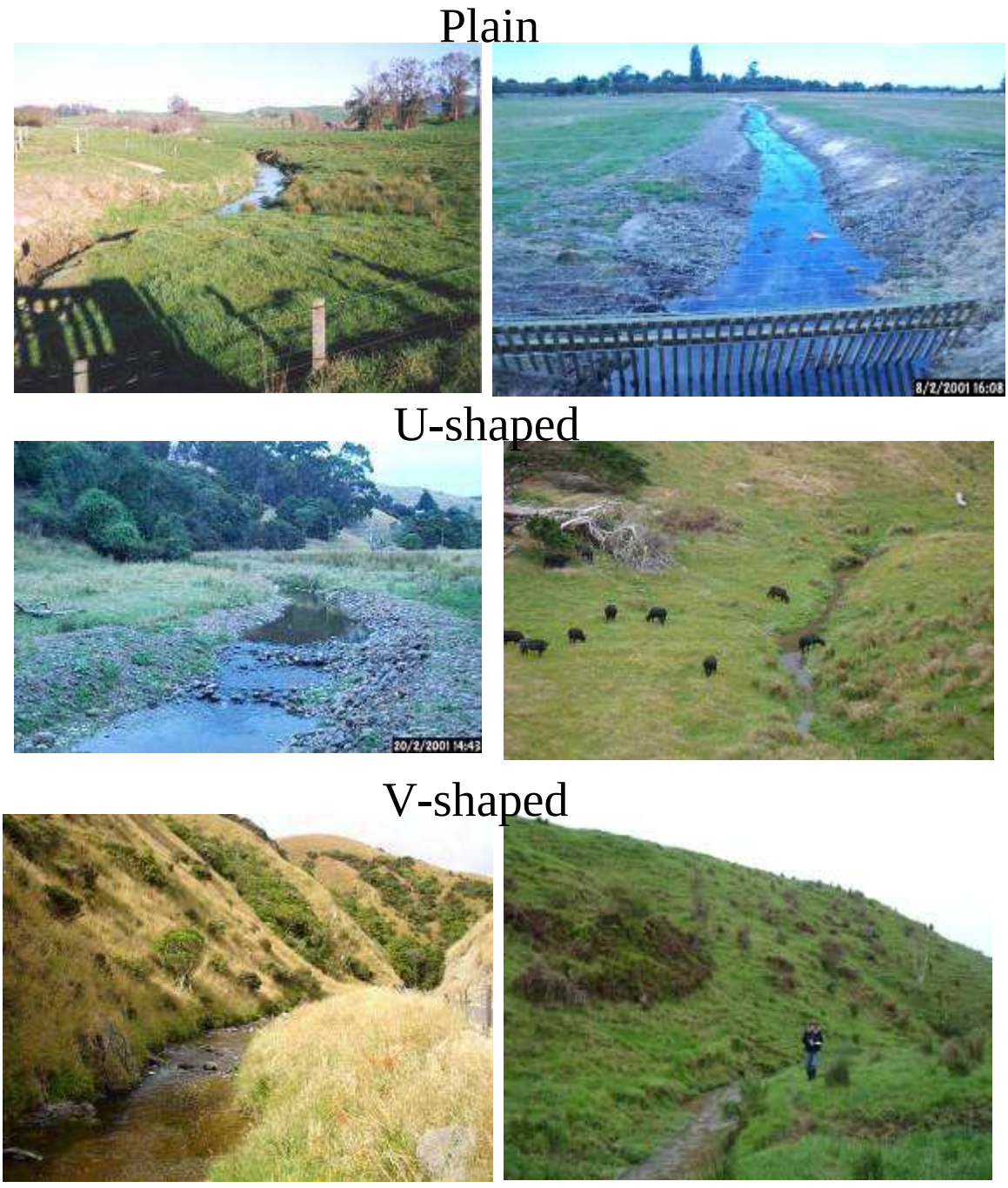


Figure 10: Examples of plain, U-shaped and V-shaped valley forms used in RMC state assessment.

3.9 Stream flow permanence

Stream flow permanence influences the instream values that riparian zone management can affect. The categories used are: ephemeral (carry water in wet weather events), intermittent (typically dry up in summer or reduced to residual, non-connected, pools), perennial (usually run year round) and wetlands (seasonally or permanently saturated soils).

3.10 Stream shade

Stream shade is assessed over the entire channel throughout the survey reach (*not* just mid-channel), taking into account the effects of streambanks, riparian vegetation and hillslopes, throughout the day (*not* just mid-day). Shade is often patchy so the observer needs to integrate these variations to assess an average value for the whole reach. Estimates are as a percentage of the "open" condition (i.e., full 180° as on an unshaded hilltop or plain). An "open" stream will have little shade (e.g., <20% of the bed) and sunlight reaches most of the stream bed, whereas a heavily shaded reach will contain riparian vegetation, topography and/or human structures (e.g., culverts) which shade >80% of the bed. Examples of reaches with a range of measured shade levels (using paired canopy analysers, Davies-Colley & Payne (1998) are provided in Figure 11 as a guide to estimates.


Shade = 99%


Shade = 95%


Shade = 84%


Shade = 84%


Shade = 81%


Shade = 70%


Shade = 70%


Shade = 68%


Shade = 64%


Shade = 26%


Shade = 23%


Shade = 21%

Figure 11: Reach photographs and shade levels measured with paired canopy analysers.

3.11 Reach sketch drawing and photographs

The broad site description is completed with **sketches of the stream in plan (bird's-eye) view,** in **cross-section view,** and with **photographs**. The sketches are quick schematics showing riparian areas in the context of the surrounding landforms, land management (e.g., location of fences, significant trees, raceways, buildings etc.) and the stream channel, and often capture information that is difficult to summarise in reach photographs. The photographs should include at least one representative image looking upstream and one looking downstream, as well as representative images looking towards the left and right banks. A high elevation photograph of the whole reach is also often useful and may replace the plan sketch.

3.12 Streambed substrate type

Streambed substrate has a strong influence on instream values and how water is exchanged between the stream, groundwater and riparian areas. Clay/mud is very fine and, when handled, typically holds together in clumps. Silt and sand are progressively coarser, larger particles and typically disperse when handled. Gravel substrate is >2 mm, cobbles are 64-256 mm and boulders are >256 mm across the stone "b" axis (width).

3.13 Flow habitat classification

The percentages of the flow types **riffles, runs and pools** along a stream reach provide information on the stream slope and the types of habitat available for instream biota that may interact with riparian vegetation. Each flow habitat type (e.g., Fig. 12) can generally be characterised by depth and surface velocity: **Riffle** – shallow depth, moderate to fast water velocity, with mixed currents, surface rippled (class includes rapids (surface broken)) and chutes/falls in this simplified classification); **Run** – character in between that of riffle and pool, slow - moderate depth and water velocity, uniform – slightly variable current, surface unbroken, smooth to slightly rippled; **Pool** – deep, slow flowing with a smooth water surface, usually where the stream widens and/or deepens.

Figure 12: Example of riffle, run and pool classes in Waitao Stream, Bay of Plenty.

3.14 Streambank height

Bank height influences the ability of the riparian vegetation to enhance streambank stability, provide cover for fish, interact with groundwater inflows and slow flood flows. Streambank height is measured from the streambed to the top of the bank where water can escape the channel at high flows. The RMC separates the low banks on the margin of the unvegetated active channel and the high banks that control flow into the broader valley floodplain (e.g., Fig. 13). Upper and lower banks may be differentiated by a change in slope. Where there is no obvious change, lower bank height equals upper bank height.

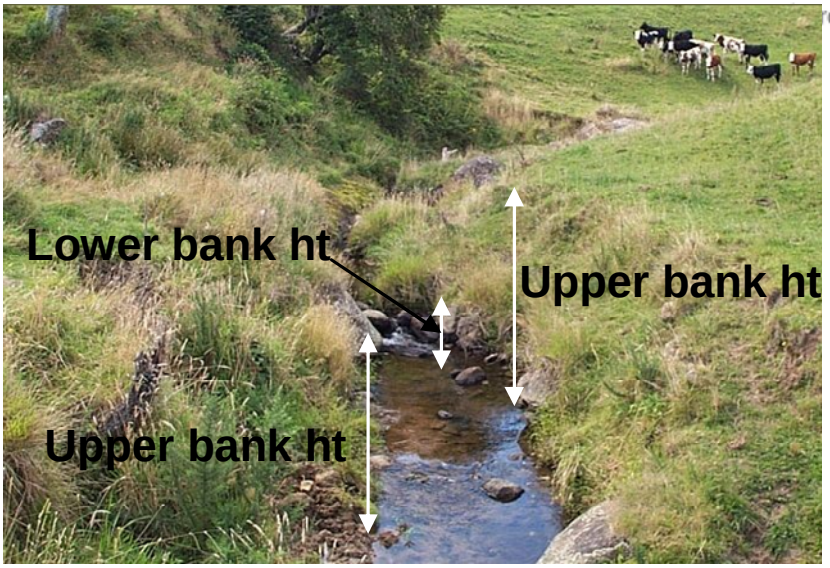


Figure 13: Examples of lower and upper streambank heights in RMC state assessment.

3.15 Streambank stability

Streambank stability has strong influence on sediment delivery to streams and therefore local habitat quality. Riparian management influences stability by controlling livestock access and through the effects of riparian vegetation (see section 4.3.1). The RMC state assessment includes an overall assessment of the percentages of each streambank that are stable, undercut (note that these may be stable), slumping (Fig. 14A, B) and subject to earthflow (i.e., sediment input from a hillslope rather than just the streambank, Fig. 14C).

The type of **bank stabilising vegetation or other features** that contribute to stream bank stabilisation are identified by circling the listed features (grasses, shrubs, sedge/rushes, trees, bedrock and riprap/artificial structures) and ticking the dominant feature.

Figure 14: Stream bank examples of (A & B) slumping, (C) earthflow erosion and (D) a stable undercut.

3.16 Macrophytes

Instream **macrophytes** may be affected by riparian shade and riparian impacts on nutrient and sediment supply. Evaluate the average % cover of the streambed throughout the reach and, if known, the species present. For example the stream reach on the front cover of this guide had approximately 20% cover by watercress. A guide to aquatic plant identification is available on the NIWA website at http://www.niwa.co.nz/our-science/aquatic-biodiversity-and-biosecurity/our-services/all/aquaticplants/outreach. Species that are not recognised in the field can usually be identified in the office with reference to the web guide from a specimen (ideally including flowers, stored on ice or dried out between sheets of absorbent paper) and/or photographs of the plants in the field.

3.17 Periphyton

Periphyton is also influenced by riparian shade and riparian controls on nutrient and sediment supply. Assess periphyton abundance using classes adapted after Jowett and Richardson (1990) and Biggs (2000) by viewing the streambed and feeling the surface cover on stones. If applicable, pick up several rocks to distinguish between bare rocks (none) and those with thin biofilms (slippery). Obvious growths are those that are clearly visible as green or brown growths. Abundant growths include filamentous

algae or periphyton mats (defined as >3mm thick to distinguish these from thinner biofilms) (Fig. 15). Periphyton is classed as excessive (in terms of aesthetic effects) when >30% of the bed is covered by filamentous growths or >60% is covered by mats (Biggs 2000).

Figure 15: Periphyton cover as filamentous green algae and a thick diatom mat (bottom, photo from Biggs 1990).

3.18 Wood

Wood is a key habitat element in streams and plays a variety of geomorphic and ecological roles (Meleason et al. 2002; Meleason et al. 2005) and is strongly influenced by riparian vegetation type and age. Wood abundance within the active channel (i.e., total within and above the wetted and unvegetated area of the channel) is classed as "absent", "sparse" (isolated pieces, < 2% cover of the bed), "common" (2-10% cover) or "abundant" (>10% cover). This includes wood that is both living (Fig. 16A) and dead, small and large (Fig. 16B-D).

Figure 16: Wood in streams examples. A, Live wood; B & C, Coromandel streams showing common and abundant wood levels; D, Central NI stream with abundant wood. Photos A & D, Rob Davies-Colley, NIWA.

3.19 Livestock access and damage

Livestock access to the stream from the left and right banks is inferred from fencing, adjacent land use and obvious signs (tracks, hoof marks, pugging, dung, and vegetation grazing). Brief notes can be added in the sketch space provided on partial access (e.g., single wire electric fencing allowing sheep access but not cattle).

The level of **livestock damage to streambanks** is rated as “none”, “minor”, “moderate” or “extensive”. Figures 17 and 18 provide examples of these ratings.

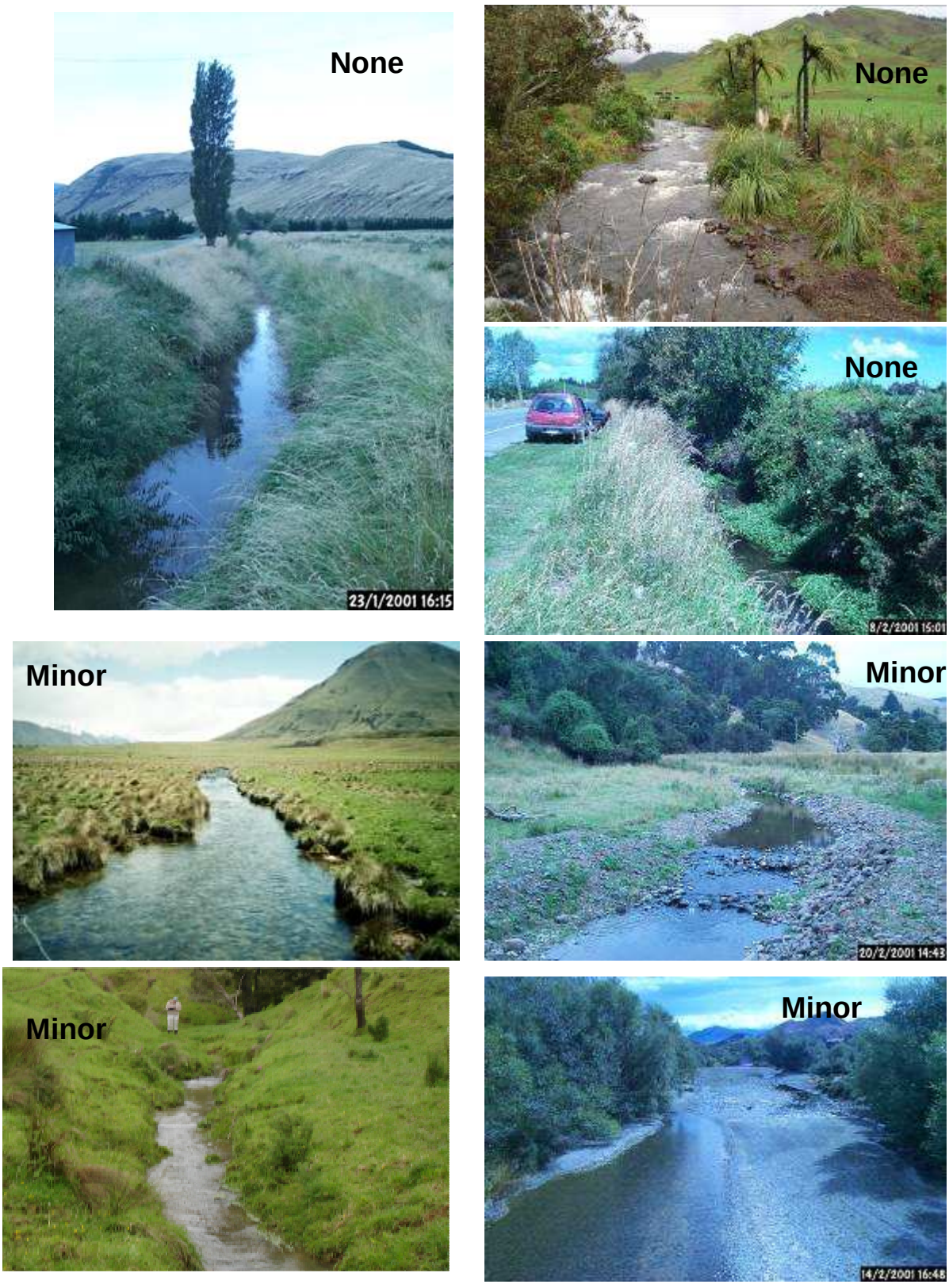


Figure 17: Examples of livestock stream damage to streambanks rated as none and minor.

Figure 18: Examples of livestock stream damage to streambanks rated as none to extensive.

3.20 Riparian vegetation

Riparian vegetation cover types present within the riparian area (i.e., to 10-20 m from the streambanks, or to an obvious natural riparian zone outer edge) on the left and right of the stream are noted by marking L and/or R next to the vegetation types present. The dominant vegetation type in the riparian area on each side of the streams is also recorded.

3.21 Local land slope angle and length

The local land slope from the top of the hillslope draining to the riparian area is a potential source of **surface runoff** and associated contaminants. The length of the land sloping to the left and right of the stream edge from the upslope ridge is assessed to provide information on the likely local source of runoff passing through the riparian areas.

3.22 Riparian wetlands

Riparian wetlands are important sites for intercepting sediment and removing nitrate in groundwater en route to the stream. Water-logged soils are moist and soft underfoot and often have wetland plants present, such as sedges, flax or raupo (Fig. 19). Note the amount of wetland along each bank by circling one of the abundance classes (absent, sparse, common or abundant).

Figure 19: Examples of riparian wetlands.

4. Riparian Function Assessment

4.1 Introduction

Riparian function assessment is the key aspect of the RMC. It involves rating the activity of twelve separate riparian functions that influence stream habitat, water quality, hydrology, and recreational use under three scenarios: **current** conditions, and after instigation of **pragmatic steps** or **best practice** riparian management.

The twelve riparian zone functions (e.g., provision of shade for stream plant and temperature control) are assessed on a 0 to 5 scale as follows:
0 = function absent; 1 = very low activity; 2 = low-moderate activity;
3 = moderate activity; 4 = high activity; 5 = very high activity.

The following sections provide key background concepts on each function and RMC rating guides. Owing to the diversity/complexity of situations that will be encountered in the field, rating assessment cannot be totally prescriptive (without being very long-winded) and some judgement calls will be required in the field. Figure 20 provides an example of a completed RMC function rating form. Figures 21a-f provide photographs with examples of RMC scores for current conditions at eighteen reaches, covering a variety of conditions, which can also be used to benchmark function activity ratings.

After the **current** condition has been assessed, assessments are repeated for the riparian conditions that are expected to develop in a medium time frame (2 decades) with **pragmatic steps** that the land manager is likely to adopt and maintain (with a modest level of support from the regional council).

Finally, the functions are re-rated for conditions expected about 20 years after adoption of **best practice** riparian management appropriate for the geographic setting. This typically involves fencing to exclude livestock and establishing a filter strip of dense groundcover or woody vegetation (trees and/or shrubs) or combinations of these in tiers (e.g., a filter strip adjacent to the pasture next to woody vegetation adjacent to the stream) (ECan 2005). The management practice and resulting riparian infrastructure (fences) and vegetation are those summarised by the surveyor in the best practice sketch at the bottom of the back page of the RMC field sheet (e.g., Fig. 20).

The timeframes for various functions to be fully established vary widely from months-years (livestock exclusion) to decades (shade along wide streams) to centuries (wood input), as discussed below. These timescales may be included in evaluations depending on the timeframe of policy/management objectives.

Riparian function assessment (score 0 = absent, 5 = very highly active)

Function	Current	Prag' steps	Best practice	Comments
Livestock excreta input & damage control	2	3	5	
Bank stabilisation	L 4	L 5	L 5	
	R 3	R 5	R 5	
Overland flow filtering	L 1	L 2	L 5	Flat land so narrow grass buffer will be effective
	R 1	R 2	R 5	
Nutrient uptake by riparian plants	L 1	L 2	L 4	
	R 1	R 2	R 4	
Denitrification	L 1	L 1	L 2	
	R 1	R 1	R 2	
Shading	1	1	2	
Leaf litter input	0	1	2	
Wood input	0	0	1	
Enhancing in-stream fish habitat	1	2	3	
Controlling downstream flooding	1	2	3	
Human recreation	1	1	4	
Aesthetics	1	2	4	

Sketch stream cross-sections & key elements of current situation (if not already done in state assessment), pragmatic (first steps) and best practicable riparian management: (including where planting zones occur, general vegetation types (grasses/sedges, shrubs, trees) & fence positions).

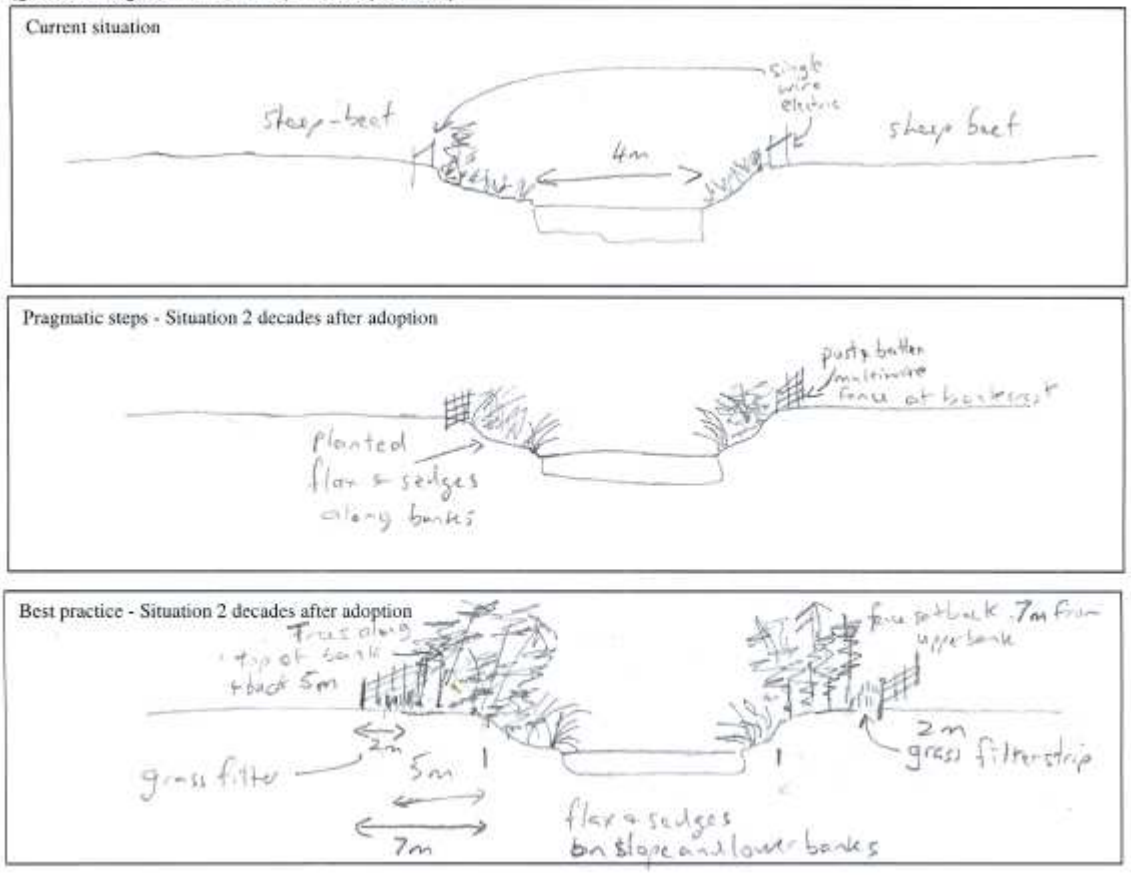


Figure 20 Example of a completed RMC function assessment form (for the Northbrook at Marsh's Rd).

Paired upstream and downstream reach views and RMC ratings at th ree Ohariu reaches

ExStk 0
BStab 1
Filt 1
NutUp 1
DeN 1
Shade 0
Wood 0
Leaf 0
FishCov 1
DsFld 1
Rec 1
Aes 2

ExStk 0
BStab 4
Filt 4
NutUp 3
DeN 2
Shade 3
Wood 0
Leaf 1
FishCov 2
DsFld 3
Rec 0
Aes 1

ExStk 0
BStab 3
Filt 2
NutUp 1
DeN 1
Shade 1
Wood 0
Leaf 0
FishCov 1
DsFld 1
Rec 2
Aes 2

Figure 21a: Examples of river/riparian reaches and RMC riparian function assessments for current conditions. ExStk = control of direct input of livestock excreta; BStab = streambank stability; Filt = filtering particulates from surface runoff; NutUp = Uptake of nutrients in groundwater by plants; DeN = removal of nitrate in groundwater inflows by denitrification; Shade = shade control of instream plant growth and water temperatures; Wood = input of wood to the stream; leaf = input of leaf litter; FishCov = provision of cover to fish; DsFld = downstream flood mitigation due to flood waters being slowed by riparian vegetation; Rec = enhanced site recreational use/value; Aes = enhanced site aesthetics. Scale = 0 (function not active) to 5 (function highly active) – see text for details.

Paired upstream and downstream reach views at three Ohariu reaches and RMC ratings

ExStk 0
BStab 3
Filt 2
NutUp 1
DeN 1
Shade 1
Wood 0
Leaf 0
FishCov 1
DsFld 1
Rec 1
Aes 1

ExStk 1
BStab 3
Filt 2
NutUp 1
DeN 0
Shade 1
Wood 1
Leaf 1
FishCov 1
DsFld 1
Rec 1
Aes 2

ExStk 5
BStab 4
Filt 4
NutUp 3
DeN 1
Shade 5
Wood 3
Leaf 5
FishCov 4
DsFld 2
Rec 2
Aes 3

Figure 21b: RMC current function rating examples continued (Ohariu Valley). See Fig 21a for function abbreviation definitions.

Current RMC ratings at three Cam catchment reaches

Figure 21C: RMC current function rating examples continued**.** The function ratings in the upper example differ between the left and right sides, as shown. The lower example is the Northbrook reach used in the example RMC forms in this manual. See Fig 21a for function abbreviation definitions.

Current RMC ratings at three Cam catchment reaches

ExStk 1
BStab 4
Filt 2
NutUp 2
DeN 1
Shade 3
Wood 2
Leaf 2
FishCov 2
DsFld 1
Rec 3
Aes 2

ExStk 1
BStab 4
Filt 2
NutUp 1
DeN 1
Shade 2
Wood 1
Leaf 1
FishCov 2
DsFld 1
Rec 3
Aes 2

ExStk 5
BStab 4
Filt 5
NutUp 4
DeN 3
Shade 2
Wood 1
Leaf 1
FishCov 3
DsFld 4
Rec 4
Aes 4

Figure 21d: RMC current function rating examples continued (Cam catchment). See Fig 21a for function abbreviation definitions.

Current RMC ratings at three Ashley catchment reaches

ExStk 5
BStab 5
Filt 5
NutUp 5
DeN 3
Shade 1
Wood 2
Leaf 2
FishCov 1
DsFld 2
Rec 5
Aes 5

ExStk 5
BStab 3
Filt 5
NutUp 4
DeN 1
Shade 5
Wood 5
Leaf 5
FishCov 4
DsFld 4
Rec 5
Aes 5

ExStk 5
BStab 5
Filt 3
NutUp 3
DeN 2
Shade 5
Wood 0
Leaf 2
FishCov 4
DsFld 3
Rec 0
Aes 1

Figure 21e: RMC current function rating examples continued (Ashley Catchment)**.** See Fig 21a for function abbreviation definitions.

Current RMC ratings at three Waitao catchment reaches

ExStk 5
BStab 4
Filt 4
NutUp 3
DeN 2
Shade 2
Wood 2
Leaf 2
FishCov 3
DsFld 2
Rec 2
Aes 1

ExStk 5
BStab 4
Filt 3
NutUp 3
DeN 1
Shade 3
Wood 2
Leaf 3
FishCov 3
DsFld 2
Rec 3
Aes 2

ExStk 5
BStab 5
Filt 3
NutUp 4
DeN 3
Shade 4
Wood 4
Leaf 4
FishCov 5
DsFld 4
Rec 5
Aes 5

Figure 21f: RMC current function rating examples continued (Waitao Catchment). See Fig 21a for function abbreviation definitions.

4.2 Controlling direct livestock excreta input and damage to stream banks and bed

4.2.1 Background

Dairy cows and cattle have been reported to void 1 - 4% of their dung and urine directly to water and riparian areas when they have unrestricted access to small streams in the Waikato (Bagshaw 2002), with significant impacts on stream nutrient and pathogen levels. Cow crossing points have also been identified as important sources of faecal input, with cows much more likely to defecate when crossing a stream than elsewhere on dairy farm raceways (Davies-Colley et al. 2004). Fencing to control livestock grazing in riparian areas reduces erosion caused by livestock trampling (e.g., streambank slumping damage under the weight of heavy livestock) and the direct impact of rainfall on soil exposed by grazing (Trimble & Mendel 1995).

Fencing livestock from riparian areas on both sides of the stream and providing bridges or culverts at regular stream crossings are key pragmatic steps in on-farm mitigation of pastoral impacts on waterways and are core elements of the Dairying and Clean Streams Accord. Fencing of the stream to exclude animals from riparian areas needs to match the livestock type, with single wire electric fences adequate for cows but post and batten fences or multi-wire electric fences needed to exclude sheep, pigs and goats and high mesh fences needed for deer. In some instances, natural features such as high stream banks or deep water near the stream edge act as natural barriers to livestock access, without fencing. Livestock management (e.g., low stocking rates) and provision of alternative water and shade within paddocks can also reduce the livestock pressure on streams.

4.2.2 RMC rating guide to control of direct livestock excreta input and damage

0 = Uncontrolled livestock access to stream (e.g., Fig. 21a)

1 = Partial control of cow or deer access to stream but riparian area largely unprotected and sheep have access e.g., single wire electric fence (dairy or beef) or deer fence along stream bank on one side; or drinking troughs in paddock; or high banks/deep water deter livestock access; no fencing but low grazing pressure

2 = Full control of cattle (but not sheep) access to stream but riparian area unprotected; e.g., single wire near stream bank on both sides of stream (e.g., Fig. 21d)

3 = Full control of all livestock access to stream but riparian area unprotected and livestock drinking watering-point access maintained; e.g., post and batten or deer fence near the streambank on both sides of stream or single wire electric fence if farm is dairy with not sheep.

4 = Full control of all livestock access to stream and riparian area but livestock drinking watering-point access maintained; e.g., post and batten or deer fence set back 5-10 m from streambank on both sides of stream

5 = Access of all livestock to the riparian area and stream prevented consistently on both sides of stream and stream crossings are bridged or culverted (Fig. 21e,f).

Stream water quality improvements are expected to respond within weeks to months to livestock exclusion by fencing and bridging (Donnison & Ross 2004; McDowell 2008).

4.3 Streambank stabilisation

4.3.1 Background on bank stabilisation

Streambank stabilisation by riparian vegetation depends on the ability of the vegetation to: (1) reinforce bank strength through root network strengthening (Lyons et al. 2000; Rutherfurd et al. 1999), (2) provide a well-developed turf or a dense root system that protects against surface soil erosion (Dunaway et al. 1994; Murgatroyd & Ternan 1983), (3) pump out water from the soil, and provide macropores for drainage, lowering erosion potential owing to bank sloughing and slumping (Thorne 1990), and/or (4) buttress the toe of the streambank protecting it from shear failure (Thorne 1990). Key factors influencing these stabilising functions are: the height of the streambanks relative to the depth of root penetration, bank angles, the erosive power of the stream under high flows (including local effects such as whether the reach is straight or meandering with many erosion-prone bends), and whether the banks are protected by other features (e.g., boulders, bedrock or large woody debris).

Grasses, herbs and forbs are expected to provide good bank stabilisation of small banks (< 0.5m) and those with low angles (< 45°), whereas shrubs and trees give

better protection for higher and steeper banks (Abernathy & Rutherfurd 1999; Burckhardt & Todd 1998). Groundcover (typically up to 1 m high including prostrate shrubs, grasses, sedges and forbs) provide reinforcement of banks to a depth < 0.3 m. Understorey trees (1-5 m high) typically have roots down to about 1 m and extend laterally to about the dripline. Overstorey species generally have a central rootball or rootplate of dense roots that can usually be considered as half a sphere that has a diameter 5 times that of the trunk. Root density declines rapidly beyond the root ball and for reinforcement purposes there are usually few roots beyond the canopy dripline or below about 2 m under bank surface. Watson et al. (Watson et al. 1999) report maximum root depths of 1.8 - 3.1 m for 8 to 25 year old *Pinus radiata* and 1.3 - 1.6 m for 6 to 32 year old kanuka. The root stabilization function will be greatest where the bank height is less than the depth of root penetration. Stabilising high vertical banks often requires that they are contoured to reduce their angle (e.g., to < 45°) before planting to enable roots to penetrate below the scour level.

Pasture streams may become narrower than under forest, owing to high sediment supply and light that enabling pasture grasses to invade the former channel margins and build up banks by trapping sediment (Davies-Colley 1997). Although this has been observed in many parts of the world, it was not observed in a survey of streams in the Nelson region (Baillie & Davies 2002), and the effect in Waikato streams decreased with stream size up to a channel width of 10 m above which the effect disappeared. Davies-Colley (1997) predicted that re-establishment of complete forest canopy closure over such small pasture streams would result in a period of increased instability as the channels widened out to their natural forest channel width, followed by stabilization of the banks along the wider channel.

4.3.2 RMC rating guide for streambank stabilisation

0 = banks bare of vegetation

1 = banks poorly vegetated/heavily grazed or vertical banks with veg. rooting depth of vegetation <1/3 of bank height (e.g., grasses on 1 m high vertical bank or overstorey trees on 5 m high vertical bank)

2 = banks moderately vegetated or vertical banks with veg. rooting depth of vegetation 1/3-2/3 of bank height (e.g., grasses on 0.5 m high vertical bank; shrubs on 1.5 m high vertical bank)

3 = banks well vegetated by plants with rooting depth = streambank height (e.g., pasture grass on <45° banks edge height 0.3 m); or vegetation with roots to > 1.5 x bank height but patchy so that < half length is well-protected

4 = Vegetation has rooting depth 1-2 x bank height

5 = Vegetation has rooting depth >2 x bank height and is permanently protected from livestock damage (e.g., tussock/sedges on <0.2 m high banks; shrubs on <0.5 m high vertical banks; trees on 1 m high vertical banks)

4.4 Filtering contaminants from overland flow

4.4.1 Background

To be effectively filter contaminants from overland flow, the riparian zone needs to: (1) slow the flow of surface runoff to increase the time for particulates to settle; and/or (2) increase infiltration into the soil to enhance filtration of particulates (Cooper et al. 1995; Lowrance et al. 1997; Phillips 1989a; Phillips 1989b; Smith 1989; Williamson et al. 1996). These filtering and settling functions are enhanced by flat topography, dense ground cover of grassy vegetation or litter under riparian forest that increase surface roughness, and soil characteristics that increase hydraulic conductivity (low compaction, high sand content, abundant macropores). Obviously, the riparian zone must receive surface runoff from the adjacent landscape for this filtering role to operate.

The filtering function will be compromised if the surface runoff is channelised, so that runoff passes rapidly through the riparian area with little time for settling of particulates or infiltration into riparian soils. The likelihood of surface runoff occurring decreases with soil infiltration rate and increases with rainfall intensity, slope length, slope angle, and convergence of flows into channels. Animal trampling typically reduces infiltration rate (Nguyen et al. 1998). In contrast, excluding stock from the riparian reverses this effect (Cooper et al. 1995). The quantity of sediment carried in surface runoff increases with the clay content (fine particles that are slow to

settle) of the soil. Guidelines are available to predict the optimal width of grass strip (% hillslope length) to filter suspended sediment from surface runoff in relation to slope length, slope angle, drainage and clay content (Collier et al. 1995).

4.4.2 RMC rating guide for filtering particulates from overland flow

0 = banks bare or short veg with high soil compaction

1 = short (grazed) veg. with high level of soil compaction; or mod. veg. length (ca. 10 cm) but most of flow passes through area in channels/rills; or mod. veg. length (ca. 10 cm) but low soil porosity (clay); or buffer width totally inadequate for slope angle, length & particle load draining to riparian area (e.g., 1-2 m along v-shaped valley with 100m long 30° land slopes of sheep/beef grazed pasture)

2 = mod cover of grass (>10 cm) or med litter layer (3-5 cm); mod channels/rills; mod compaction, mod porosity (silty) soil (e.g., macropores abundant, sandy soil); buffer width barely adequate for slope angle & length & particulate load of land draining to rip area

3 = mod cover of grass (>10 cm) or med litter layer (ca. 5 cm); few channels/rills; uncompacted, moderately porous (silty) soil (e.g., macropores abundant, sandy soil); buffer width almost adequate for slope angle and length and particulate load of land draining to rip area

4 = dense groundcover of grass (ca. 20 cm high) or thick (>10 cm) litter layer; minor channels/rills; uncompacted, highly porous soil buffer width adequate for slope angle and length and particulate load of land draining to rip area

5 = dense groundcover of grass or thick litter layer; no channels/rills; uncompacted, highly porous soil (e.g., macropores abundant, sandy soil); buffer width more than adequate for slope angle and length and particulate load of land draining to riparian area

4.5 Nutrient uptake by riparian plants

4.5.1 Background

Nutrient uptake by riparian plants is an important function where infiltration surface runoff or shallow groundwater passes through the root zone before entering the stream (Fig. 20). In contrast, the function is unimportant where groundwater bypasses the root zone of riparian plants. This may occur in deeply incised streams, where tile drains deliver most of the shallow groundwater directly to the stream, or where deep groundwater emerges in the streambed as springs (Hill 1996; Prosser et al. 1999).

Nutrient uptake by riparian plants varies with the vegetation rooting depth in relation to bank height and groundwater flows – larger trees and shrubs have deeper roots that can intercept deeper groundwater. Large plants also have a greater biomass and hence

generally store more nutrients in plant tissue than small plants. Harvesting of these plants (e.g., by timber harvest or controlled animal grazing and subsequent removal of the animals) contributes to long-term removal of these stored nutrients from the riparian area. Plants nearest the stream are most likely to interact with groundwater, but nutrient uptake is expected to increase with the width of the zone of deep-rooting riparian plants.

The transpiration of riparian vegetation can also pump water from riparian soils, leading to hydraulic gradients that draw river water into the riparian area where it is exposed to nutrient uptake and removal processes.

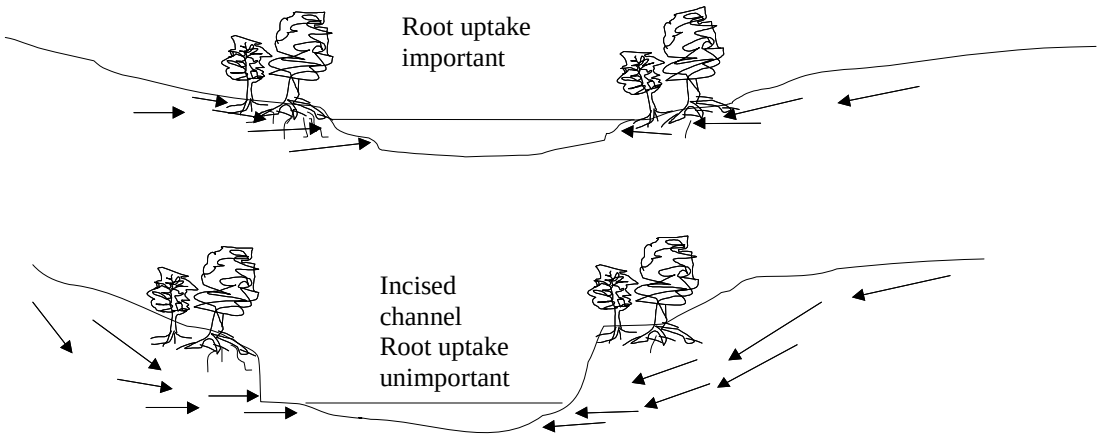


Figure 20: Schematic showing the influence of channel shape on interaction between shallow groundwater and the riparian vegetation roots.

4.5.2 RMC rating guide for nutrient uptake from groundwater

0 = banks bare of vegetation

1 = banks poorly vegetated or rooting depth of vegetation <1/2 of bank height above normal water level (e.g., grasses on 1.2 m high bank or overstorey trees on 5 m high bank)

2 = narrow buffer (≤ 5 m wide) of veg. with rooting depth ca. 1/2 bank height above normal water level (e.g., grasses on 0.5 m high vertical bank; shrubs on 1.5 m high vertical bank)

3 = narrow buffer (≤ 5 m wide) of veg. with rooting depth to water level at baseflow

4 = medium buffer (5-10 m wide) of veg. with rooting depth to water level at baseflow

5 = wide buffer (≥ 10 m) of vegetation has rooting depth >2 x bank height to water level at baseflow (e.g., tussock/sedges on <0.2 m high banks; shrubs on <0.5 m high vertical banks; trees on 1 m high vertical banks)

4.6 Denitrification

4.6.1 Background

Denitrification is a process by which bacteria reduce nitrate to the gases nitrous oxide and N_2 that are lost to the atmosphere, providing permanent N removal from the water (Hill 1996; Willems et al. 1997). The process requires nitrate N, low oxygen conditions provided by waterlogged soils, and an available carbon source to drive the process (Knowles 1982). It is most important in riparian areas where shallow groundwater passes through wetlands before emerging in the stream (Cooper 1990; Prosser et al. 1999).

Riparian plants enhance the process by their roots increasing the supply of carbon at depth within the streamside soils. Removal of livestock from riparian wetlands enhances denitrification performance by reducing pugging, allowing carbon to accumulate and preventing accumulation of faecal pathogens (Collins 2004). These effects are expected to begin to occur within months of livestock exclusion and increase over the following 2-5 years, provided that the other conditions for wetland development are present.

4.6.2 RMC rating guide for denitrification of groundwater inflows

0 = banks bare of vegetation or grassed over dry, free-draining soils (sand/gravel).

1 = banks poorly vegetated; or veg. rooting depth <1/2 of bank height above normal water level (e.g., grasses on 1.2 m high bank or overstorey trees on 5 m high bank) or grass buffer on free-draining/dry soils

2 = narrow riparian forest vegetation buffer (≤5 m wide) on soils that are moderately drained (e.g., silts) and typically moist but unsaturated

3 = wide buffer (>10 m) of riparian forest vegetation on soils that are moderately drained (e.g., silts) and typically moist but unsaturated.

4 = medium of wetland/swamp forest vegetation buffer (2-5 m wide) with rooting depth to water level at baseflow and saturated soils

5 = wide wetland/swamp forest vegetation buffer (≥5 m) with rooting depth >2 x bank height to water level at baseflow, soils saturated

4.7 Shading for instream temperature and plant control

4.7.1 Background

Cool groundwater entering shallow streams heats quickly under direct solar radiation in unshaded conditions (Quinn et al. 1992; Rutherford et al. 1997; Rutherford et al. 1999). The rate of heating decreases with stream depth, as the mass of water absorbing the incident radiation increases, and with shading vegetation, that absorbs and reflects much of the incident radiation. The ability of riparian vegetation to shade the channel decreases with stream width and the height of the vegetation (Davies-Colley & Quinn 1998). Mature trees produce a closed canopy over channels narrower than about 6 m but the "shade gap" between the trees on either banks increases above this channel width (Davies-Colley & Quinn 1998). Tussock grasses, sedges and flaxes only provide effective shade in very narrow channels (i.e., < c. 2m). Streams with poorly conductive beds (e.g., clay or bedrock) are expected to heat more rapidly than equivalently shaded streams with conductive beds (e.g., gravels), due to less conductive loss to the ground and less exchange with groundwater. Streambanks and hills can also provide topographic shade, independent of riparian vegetation, and are particularly important in incised streams (Rutherford et al. 1999).

Riparian shade can control stream lighting and thus control instream plant growth below nuisance levels, whilst maintaining the biodiversity benefits and desirable functions that plants provide (Biggs 2000). Shading of 60-80% is expected to prevent proliferation of filamentous green algae (Davies-Colley & Quinn 1998; Quinn et al. 1997b), but 90% shading is needed to prevent growth of some emergent macrophytes in low gradient streams (Wilcock et al. 1998).

Studies of stream temperature response to riparian vegetation change through various forms of riparian revegetatation along small streams (1-2 m wide) at Whatawhata (Quinn et al. 2009) and small-medium Coromandel streams (2-12 m wide) with riparian vegetation regeneration after forest clearcutting (Quinn & Wright-Stow 2008) have provided empirical information on the time taken for shade recovery. Five years after riparian planting with native vegetation, mean summer water temperature was still 1°C and 2.3 °C higher in streams with 1 and 2 m wide channels respectively, than in a native forest reference stream (Quinn et al. 2009). Rates of recovery of thermal regimes after logging of Coromandel Peninsula pine plantation streams were strongly negatively correlated with stream size. Summer daily mean and maximum temperatures declined during the riparian vegetation regrowth phase by 0.18 and 0.47 °C $year^{-1}$, respectively, for the largest (12 m wide) stream and 1.4 and 1.9 °C $year^{-1}$ in the smallest (2 m wide) stream. Thermal regimes were restored in small streams (2–4 m wide channels) about 6–8 years after clearfelling. In medium-sized streams (6–12 m wide channels), we predict this recovery will take 12–16 years.

4.7.2 RMC rating guide for providing stream shade

0 = banks bare of vegetation and banks + riparian vegetation shade <10% of channel (considering whole 180° hemisphere and all points across stream)

1 = banks + riparian vegetation shade 10-30% of wetted width at baseflow

2 = banks + riparian vegetation shade 30-50% of wetted width at baseflow

3 = banks + riparian vegetation shade 50-70% of wetted width at baseflow

4 = banks + riparian vegetation shade 70-90% of wetted width at baseflow

5 = banks + riparian vegetation shade >90% of wetted width at baseflow

4.8 Input of wood and leaf litter

4.8.1 Background

Wood and leaf litter can play important roles in streams as food resources and habitat (Biggs 2000; Collier & Halliday 2000). The role of leaf litter and wood depends on the retentiveness of the stream, which decreases with stream size (Webster et al. 1999; Webster et al. 1994) and flooding frequency. Wood input is most stable in smaller streams, especially where the channel width is less than the typical wood piece length, and in low gradient streams that lack the power during floods to transport wood downstream. Wood can be a key habitat forming feature, increasing habitat diversity and cover for invertebrates and fish, and often forms the deepest pools (Parkyn et al. 2009; Quinn et al. 1997a). Wood is particularly important as invertebrate habitat in sandy and silty bedded streams (Collier & Halliday 2000).

The time taken for litterfall to be reestablished is likely to be similar to that for shade, as discussed above. However, natural restoration of wood to streams is a much longer term process (several decades to centuries) (Davies-Colley et al. 2009; Meleason & Hall 2005).

4.8.2 RMC rating guide for providing wood input to stream

0 = banks bare of woody vegetation (e.g., grassland, tussock, wetland sedge and flax)

1 = riparian shrub vegetation (provide limited input of small wood and roots may penetrate streambed) along medium width streams (3-6 m wide channels)

2 = riparian shrub vegetation (provide limited input of small wood and roots may penetrate streambed) along small streams (<3 m wide channels); or riparian softwoods planted for stream bank stabilisation (e.g., poplars and willows) along medium width hill-fed streams (e.g., 3-6 m wide).

3 = narrow riparian buffer (<5 m) of regenerating riparian forest along small rivers (< ca.10 m wide channel); or riparian softwoods planted for stream bank stabilisation (e.g., poplars and willows) or pine plantations along small hill-fed streams (e.g., ≤3 m wide) or along wider spring-fed streams that lack flood flows that move wood

4 = wide riparian buffer (≥20 m) of mid-succession growth (50-200 years) riparian forest along small–medium streams and rivers (< 20 m wide)

5 = wide riparian buffer (≥20 m) of old growth (>200 years) riparian forest along small–medium streams and rivers (< 20 m wide)

4.8.3 RMC rating guide for providing leaf litter input to stream

0 = banks bare of vegetation or short grazed grass

1 = riparian vegetation is long grass or wetland/flax

2 = channel poorly shaded (20-50%) by shrubs or trees or moderately shaded but has low retention of leaf input (e.g., due to combinations of depth, high current velocities, flow variability, fine sediments, lack of debris dams or encroaching vegetation)

3 = channel well shaded (>70%) by deciduous vegetation, or moderately shaded (50-70%) by evergreen vegetation, but low litter retention (e.g., few protruding substrates or debris dams, little encroaching riparian vegetation and lacking quiescent pools and backwaters).

4 = channel well shaded (>70%) by deciduous vegetation, or moderately shaded (50-70%) by evergreen vegetation, and moderate-high litter retention (e.g., shallow with protruding substrates, debris dams, encroaching riparian vegetation, or deeper with quiescent pools and backwaters)

5 = channel well shaded (>70%) by native or evergreen vegetation and moderate-high litter retention (e.g., shallow with protruding substrates, debris dams, encroaching riparian vegetation or deeper with quiescent pools and backwaters)

4.9 Enhancing instream fish habitat and fish spawning areas

4.9.1 Background

Riparian vegetation enhances fish habitat by providing cover and also encourages the input of terrestrial insect food items from overhanging vegetation (Jowett et al. 1996; Main & Lyon 1988). Cover can take the form of overhanging plants, tree roots, wood and leafpacks. Higher over-storey vegetation is less effective fish cover than low-growing grasses and shrubs that grow just above stream level or hang into the stream (pers. comm. R Allibone).

Riparian zones also provide spawning areas for some galaxiid fish species, such as banded kokopu (Mitchell & Penlington 1982), and short-jawed kokopu that spawn in leaf litter/wood on streambank during high flows (pers. comm. R Allibone), and inanga that spawn in riparian grasses in tidal lowland reaches (near the salt wedge) (Mitchell & Eldon 1991). Removal of riparian vegetation in upland areas is expected to reduce the suitability for banded kokopu spawning by eliminating the moist microclimate and leaf litter found under forest, but details of spawning requirements are unclear. Intensive stock grazing is also expected to reduce the spawning success for inanga by removing the dense grassy vegetation and by stock trampling eggs and exposing them to desiccation due to sunlight and wind during their month-long incubation period.

The evaluation of fish habitat effects of riparian management needs to be informed by knowledge of the site's likely fish communities composition and the habitat preferences of this assemblage. Predictions on native fish species occurrence are available for each REC reach throughout New Zealand (Leathwick et al. 2008b) and local ecologists are likely to be able to provide specific advice.

4.9.2 RMC rating guide for enhancing fish habitat focusing on inanga (I) and banded kokopu (BK) spawning and cover habitat and generalised for other common species such as eels and trout

0 = banks bare of vegetation or short grazed grass

1 = sparse deciduous streambank trees or long grass provides patchy, temporary, overhang cover along small streams

2 = <20% of streambank with permanent encroaching/overhanging riparian cover

3 = common bankside cover (e.g., 20-50% of streambank with some form of overhang cover) by encroaching riparian vegetation; low-moderate input of large wood as instream cover; or livestock excluded from inanga spawning areas during spawning season (autumn) only.

4 = abundant encroaching riparian vegetation (e.g., >50% of streambank with some form of overhang cover) provides bankside cover and enhances food input as terrestrial insects; high input of large wood as instream cover habitat.

5 = heavy shade (>ca.70%) over very small headwater streams (BK); rank grasses or wetland vegetation in the tidal area upstream of the salty wedge and livestock excluded permanently (Inanga spawning); riparian forest with abundant leaf litter and wood in the flood inundated zone (spawning for other kokopu species)

4.10 Controlling downstream flooding

4.10.1 Background

Riparian forest and wetlands are expected to attenuate the peak flow of runoff into the stream channel in small rainfall events (Smith 1992). Furthermore, well-developed riparian vegetation has greater hydraulic roughness than short grass and hence retards the progress of flood flows as they spill out into the riparian area (Coon 1998). This may cause increased local flooding of the riparian area and adjacent land, but is expected to reduce the peak flow in downstream reaches (Anderson et al. 2006). Factors expected to influence these effects are the likelihood of overbank flow events (less in deeply incised channels), the width of the riparian area and floodplain, the extent of wetlands, and the roughness (size/density in relation to the flow depth) of the riparian vegetation.

4.10.2 RMC rating guide for reducing downstream flooding

0 = banks and floodplain are bare or short grass or high flows remain within the non-vegetated channel and interact minimally with riparian vegetation.

1 = some (<50%) of the area of likely inundation by flood flows has vegetation with low-mod. flow resistance (e.g., native grassland, tussock, wetland sedges) that is substantially overtopped by annual flood flows; or high flows remain within the main channel and only minor interact with riparian vegetation that encroaches the channel (e.g., overhanging flax, shrubs or trees)

2 = most (>50%) of the area of likely inundation by flood flows has flexible vegetation with low flow resistance (e.g., native grassland, tussock, wetland sedges) that is overtopped by annual flood flows; or high riparian cover by stiff vegetation but flood inundation constrained by land form (e.g., in v-shaped valleys)

3 = most (>50%) of the area of likely inundation by flood flows has low-mod flexible vegetation (e.g., tussock, wetland sedges, flax, shrubs) that interacts with most of flood water.

4 = area of likely inundation by flood flows has abundant stiff vegetation (may include dead wood debris) that interacts with most of flood water. Vegetation could range from flax or tussock on a small headwater stream to old growth riparian forest in the floodplain of a large river.

5 = whole area of likely inundation by flood flows has abundant stiff vegetation (may include dead wood debris) that interacts with whole depth of flood water (ranging from flax or tussock on a small headwater stream to old growth riparian forest in the floodplain of a large river)

4.11 Human recreation

4.11.1 Background

Riparian management can influence human recreation of the riparian area and the stream by changing stream aesthetics, naturalness, access, and the fishability of the stream (Mosley 1989). These effects are generally more important along medium-sized streams, with access to safe swimming and fishing spots, and in areas of high human access, such as urban streams and reserves.

Riparian management also influences boating and canoeing. Overhanging willows and large wood can be hazardous for boating, whereas native planting plays a particularly important role in enhancing recreational use. Walkways, picnicking facilities (tables and seating), weed control (especially blackberry and other invasives) and vehicle parking areas are all important for enhancing recreational use. Angling use requires particular attention to riparian planting design to provide both overhanging cover and low vegetation to allow casting when fly-fishing. The RMC ratings for recreational use tend to be the most site specific.

4.11.2 RMC rating guide for enhancing recreational use of stream/riparian area

0 = riparian area covered in blackberry and other invasive weeds making stream edge in accessible and downstream passage in canoes hazardous

1 = minimal natural vegetation cover along small streams (e.g., < 3 m wide channels) that are relatively in accessible and not used for angling, swimming or boating on for walking areas (e.g., headwaters on farmland)

2 = native vegetation along small streams that are not used for angling or boating on relatively in accessible areas such as headwaters on farmland away; or monocultures of exotic vegetation along streams and rivers used for fishing, boating, swimming or walking

3 = varied exotic vegetation or patchy native vegetation along streams and rivers used for fishing, boating, swimming or walking

4 = mix of native and exotic forest/wetland vegetation continuous along streams and rivers used for fishing, boating, swimming or walking

5 = native forest along streams and rivers used for fishing, boating, swimming or walking

4.12.1 Landscape and stream aesthetics

4.12.2 Background

Aesthetic considerations are often a key motivation of land owners to adopt riparian management. Riparian areas can enhance landscape aesthetics substantially by providing vegetation diversity with ribbons of green within developed pastoral and urban landscapes (Mosley 1989). Shrubs and trees have generally greater aesthetic appeal than grasses, and native vegetation has more appeal than exotic vegetation. However, aesthetics are landscape dependent (e.g., tussocks may be more aesthetically desirable than trees in inland Canterbury high country streams) and vary amongst individuals. Ideally, RMC ratings of aesthetic effects of riparian management should be informed by knowledge of the land owner's perspectives on aesthetics.

4.12.3 RMC rating guide for enhancing stream aesthetics

0 = bare ground or covered in blackberry and other invasive weeds
1 = pasture with unconstrained livestock access to the stream, no trees
2 = fenced pasture grasses without livestock access to the stream; or pasture with livestock access and a 1-2 types of exotic trees (e.g., willows and/or poplars)
3 = varied exotic dominated vegetation, limited livestock access
4 = native shrubs or wetland is dominant vegetation type
5 = native forest is dominant vegetation

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