# Riparian Zone Management

Strategy for the Auckland Region

Auckland *Regional* Council

## June 2001

## Auckland Regional Council Technical Publication 148

ISSN 1175 205X

# Riparian Zone Management

Strategy for the Auckland Region

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## Foreword

The growth that has contributed so much of value to the Auckland region has taken place at some cost to the natural values of our environment. Streams, wetlands and forests have disappeared in many areas, and ongoing growth places more pressure on those that remain.

Our unique native fish need healthy streams and clear passage between open seas and inland streams, but to be healthy streams need shady trees.

Piping streams and removing their vegetated corridors reduces our catches of whitebait and eels, and affects the landscape vistas on which we gratefully rest our urban eyes.

Making the most of what remains and restoring some of what we have lost is not an impossible dream. But to be effective, we need a vision and a plan.

It is impossible to turn the clock back: we cannot restore 100% of the freshwater and riparian habitat the region has lost. However, it is possible to agree on an achievable goal that achieves reasonable environmental benefit for a reasonable cost and achieves sustainable resource management objectives.

Rather than putting a numerical goal in terms of regional coverage of riparian areas, this Strategy targets areas most likely to deliver beneficial outcomes. It spells out how established farms, lifestyle blocks, newly developing and already developed urban areas and parklands can all make a positive contribution to maintaining and enhancing our region's natural environmental values.

The Strategy envisages a mix of voluntary and long range planning tools over the long term. By providing a consistent approach to riparian protection and restoration across the region, this Strategy and its accompanying Guideline to implementation and the Planting Guide will provide practical assistance, support and inspiration to many.

I commend this Strategy, Guideline and Planting Guide to the many people, organisations and communities in our Region who have the motive and opportunity to take positive action towards sustainable environmental management by planting appropriate vegetation on stream margins.

Councillor Patricia Thorp

Chair, Environmental Management Committee
Auckland Regional Council

## Feedback Form

We will be regularly reviewing these Guidelines. Please help us keep them accurate and practical: let us know about any changes we need to make by using this form.

**Please photocopy this form before you fill it out, to keep this original for future use.**

1. The level the information was pitched at was (please circle a number):

   1 *far too low* | 2 *too low* | 3 *just right* | 4 *too high* | 5 *far too high*

2. The parts I liked best or found the most useful were (please state):

   _____

   _____

   _____

3. The parts I liked least or found the least useful were (please state):

   _____

   _____

4. How useful is the Guideline (Part B) and the Planting Guide in planning, designing, planting and maintaining a riparian management zone? Please circle a number:

   1 *far too low* | 2 *too low* | 3 *just right* | 4 *too high* | 5 *far too high*

   The parts I liked best or found the most useful were (please state):

   _____

   _____

   _____

   The parts I liked least or found the least useful were (please state):

   _____

   _____

5. How useful is the Guideline (Part B) and the Planting Guide in planning, designing, planting and maintaining a riparian management zone? Please circle a number:

   1 totally useless | 2 fairly useless | 3 not bad | 4 quite useful | 5 extremely useful

6. Please tell us your suggestions for improving the Strategy (Part A) and/or the Guideline (Part B) and the Planting Guide:

   _____

   _____

   _____

7. Do you have any other comments or questions? If so, please note them below:

   _____

   _____

8. Your contact details (Optional). Please note your name and phone number below if you would like to discuss your suggestions in more detail:

   Name: _____ Phone: _____

**Thank you for taking the time to improve our Guidelines.**

Feel free to phone us about your views on 09-366 2000, ask for the Environmental Care Co-ordinator, or **Freepost** a copy of this response form to: *Environmental Care Co-ordinator, Auckland Regional Council, Private Bag 92012, Auckland. Freepost No. 4103*

## Acknowledgements

The Strategy and Guideline has been prepared and funded by the Auckland Regional Council.

The Planting Guide has been sponsored by Transit New Zealand and the Auckland Regional Council.

## How to find out more

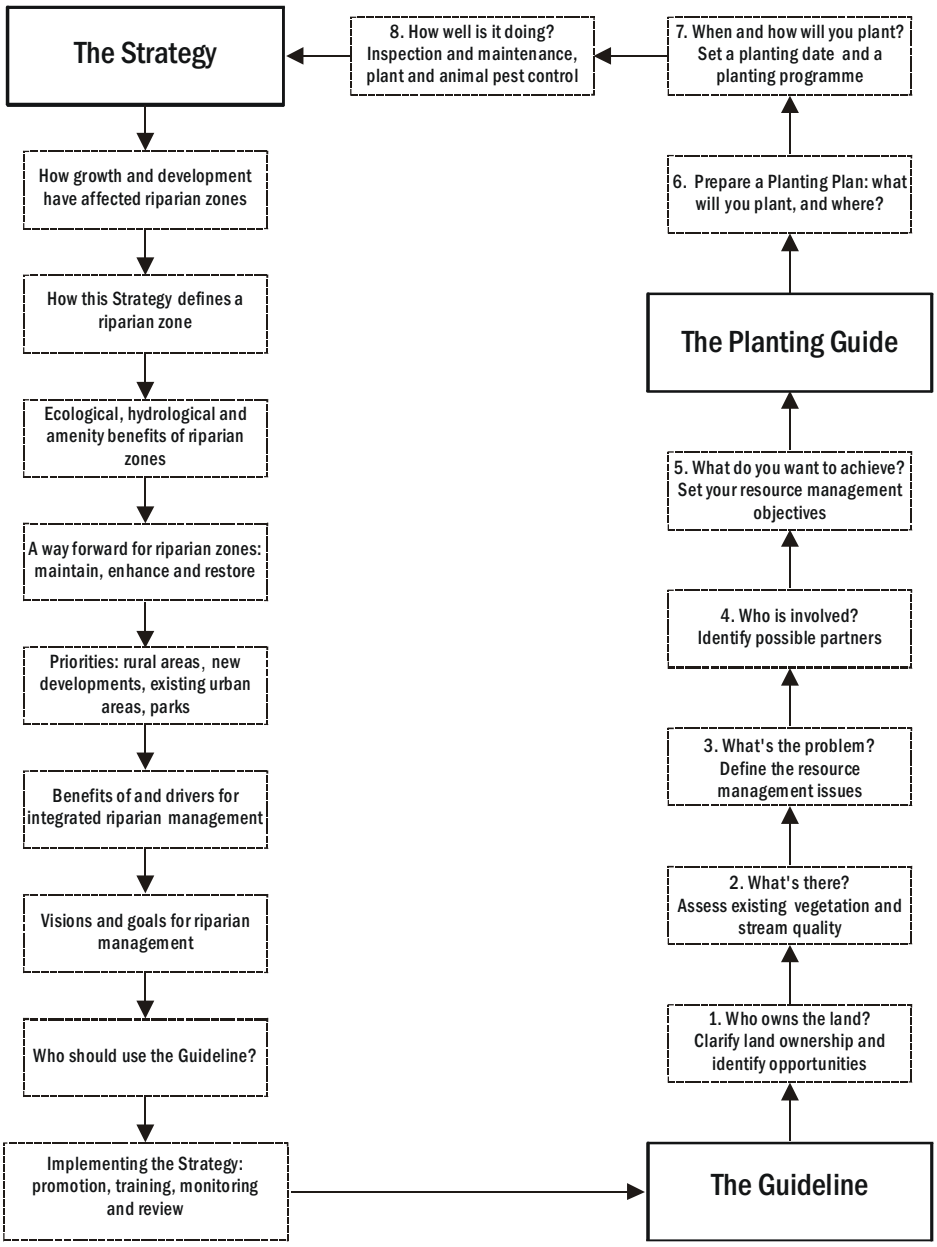
This Strategy and Guideline will be regularly reviewed and updated. To make sure you have an up-to-date version, visit the Auckland Regional Council's website at **www.arc.govt.nz** to review and, if necessary, print off the most recent edition.

The Council will also run *training workshops* as demand indicates for:

- city and district council staff who want to know more about how to encourage or require riparian zone protection, enhancement or restoration
- land owners, community groups and developers or their professional advisers who want or are required to protect, enhance or restore riparian zones

To find out more or make suggestions, contact at the Auckland Regional Council by telephone on 09–366 2000 and ask for the Environmental Care Co-ordinator.

*Figure 1* *What is in the Strategy, Guideline and Planting Guide?*



# Riparian Zone Management

Strategy for the Auckland Region

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# 1.0 Introduction and Overview

**Preview**

This section of the Strategy looks at:

- how land use change and growth have affected Auckland's waters and their margins
- key management issues related to riparian management in the Region
- the Region's vegetation and streams
- riparian resources of the region, past, present and a possible future

## 1.1 Background: how growth and development have affected Auckland's waters and their margins

The Auckland Region has an extensive coastline, three large harbours, numerous estuaries and many lakes, wetlands, rivers and streams. Over the past several hundred years land cover and land use has changed from native bush to pastoral farming and more recently, urban land use.

The pressures of land use change from rural and urban development have contributed to the erosion of catchment soils, changes in stream morphology, increased flooding, impacts on water quality and loss of riparian (stream bank and lakeside) vegetation and wetlands. The result has been a major loss of terrestrial and aquatic habitat and reduced biological diversity within catchments and waterways.

*Table 1 Predominant land uses in the Auckland Region as at 2000*
(Source: Statistics New Zealand and Terralink Land Cover Database, developed from 1996 Spot satellite imagery)

| Land Use | Area (Hectares) | Percentage |
|---|---|---|
| Pasture | 224,000 | 49 |
| Metropolitan urban | 47,000 | 11 |
| Exotic forest | 33,000 | 7 |
| Native forest and shrubland | 135,000 | 30 |
| Horticulture | 11,000 | 3 |
| **Total** (excluding Gulf islands) | **450,000** | **100** |

Table 1 shows that the Region currently has 47,000 ha of urbanised land. Future growth predictions are that the population will double over the next 50 years. Over the next ten years the metropolitan urban limits shown in Figure 1 will be realigned to accommodate some of the increased population, and about 300,000 people will be housed beyond the current limit in existing rural townships and coastal villages.

Management of the predicted population growth has been identified by the Auckland Regional Growth Forum as the top priority for the region's strategic planners and environmental managers. The Growth Forum members (representatives of all eight of Auckland's councils - four city, three district and one regional) have prepared a Regional Growth Strategy to address planning and infrastructure requirements for the next fifty years.

This growth places more pressure on what remains of Auckland's environmental values, especially riparian values, which are so important to preserving water quality and aquatic biodiversity.

This Strategy will provide a consistent approach to riparian protection and restoration across the region.

## 1.2 Key Riparian Management Issues in the Region

***Growth and land use change***

Regional characteristics documented by the Growth Forum of particular significance to riparian zone management are that (Growth Forum Regional Facts, March 1998):

- there is about 10,000 km of perennial stream length in the Auckland region (ARC, 1999)
- land use change over the past several hundred years has severely affected riparian vegetation
- it is estimated that only 19% of the total length of large streams and rivers in the Auckland region now flows through native forest or forest/scrub
- less than 10% of the Region's original wetlands remain
- less than 30% of our native forest remains, and most of this is in the Hunua and Waitakere ranges
- 56 native animals in the Region are threatened species

*Figure 2 The Metropolitan Urban Limits in the Auckland Region*

Source: Auckland Regional Council, 2000

*This diagram has been moved to* ***Part 1 – Appendix A,*** *which may be down loaded as a separate file*

*Plate 1 Earthworks at a greenfield site*
Source: Ross Winter, ARC

One of the key resource management issues arising from current growth in the region is greenfields development; that is rezoning of rural catchments for lifestyle and more intensive urban land use. The earthworks that accompany such developments directly affect riparian vegetation, water quality, stream morphology and landscape values, because streams and their riparian vegetation are often totally lost

The Auckland Regional Council receives resource consent applications for around 1000 ha of earthworks a year within the metropolitan urban limits. Over the past 10 years there has been more than 6000 ha of bulk earthworks for housing, industrial and commercial development as well as infrastructure works. These earthworks include removal of vegetation, construction of roads, preparation of building platforms and site re-contouring, before final development of housing.

To achieve the maximum number of building sites and to control the resultant increased stormwater runoff, traditional urban development involves piping streams, resulting in further loss of in-stream and riparian habitat. These land use changes increase impervious cover and alter the hydraulic characteristics of the catchment, greatly increasing the rate of runoff from storm flows to waterways and wetlands in the catchment. Increased stormwater runoff affects water quality in downstream receiving environments such as estuaries, harbours and coastal waters.

This Strategy, Guideline and Planting Guide link to other ARC initiatives such as the Low Impact Design Manual ARC (2000) to provide landowners and developers with a rationale for and practical guidance on riparian management in the Auckland Region. Protection, enhancement and restoration of existing vegetation and streams are effective resource management options for greenfields development, and can also be applied to some already developed areas.

### *Vegetation*

Native forest would have once covered extensive areas of the Auckland Region. This original vegetation would have included forest communities with kauri, rimu, taraire, puriri, tawa and pohutukawa in the canopy, and wetlands and swamp forest in the low-lying areas. Associated with the forest and wetlands was an extensive network of small streams.

At the coast the forest would have given way to salt marsh and mangrove forest in tidal inlets and estuaries, and, in more open coastal areas, to communities of native sand-binding species such as pingao and spinifex, with scrub associations on sand dunes.

*Plate 2 Construction of a culvert and associated streamworks at a greenfield site*
Source: Earl Shaver, ARC

The Auckland Region's natural vegetation, like many other parts of lowland New Zealand, has been greatly reduced from its original extent and extensively modified from its original state by vegetation clearance and land development. Of the Region's total land area, approximately 15% remains in indigenous forest. A further 11% remains in mixed indigenous and exotic shrub land communities, including successional manuka and kanuka communities, as shown in Table 1.

Most of the Region's remaining native forest has been modified by past land practices and is regenerating from clearance and milling during European settlement. Small pockets of original forest which has not been logged or burnt by human activity occur in the Waitakere Ranges and Hunua Ranges, on offshore islands and in other parts of the region.

The largest areas of native forest remaining in the Region occur in the Waitakere and Hunua ranges, and on islands such as Little Barrier and Great Barrier. In the coastal and lowland areas of the Region, where urban and rural development has been extensive, only fragments of native vegetation remain.

An estimated 14% of the Region is in protected natural areas, including DoC reserves, Regional Parks and local authority reserves. A significant amount of the Region's natural heritage resources are protected and managed in the Auckland Regional Council's extensive regional parks network, which includes regionally and nationally significant heritage resources such as the Hunua and Waitakere ranges.

In the past, therefore, the Region's streams would have been flanked by a variety of forest types, whereas now they are flanked by agricultural and urban land uses.

Figure 5 is a conceptual illustration of the past, present and possible future status of riparians zones in the Auckland Region.

***Streams***

The total length of streams in the Region is estimated to be 10,000 km. Most (89%)

are small (less than 2 meters wide) first order (no mapped tributaries, as shown in Figure 4) and second order (one tributary) streams, owing to the small and short catchments of the narrow Auckland isthmus (O'Brien, 1999).

Most of these mapped streams are perennial, with flow or stable pools throughout the year. A recent survey of first order streams found that 75% of those in rural areas and 100% of those in native bush and urban areas would support aquatic life during late summer (Maxted et al.,

*Plate 3 Stream with no riparian vegetation*

Source: John Maxted, ARC

*Plate 4 Stream with riparian vegetation*

Source: John Maxted, ARC

*Figure 3 Original (Pre-Human) vegetation and current extent of existing vegetation in Awhitu/Manukau Ecological Districts*

Source: Emmett et al, Indigeous vegetation of the Awhitu and Manukau ecological districts. Landcare Research. Prepared for ARC. January 2000

*This diagram has been moved to* ***Part 1 – Appendix A,***
*which may be down loaded as a separate file*

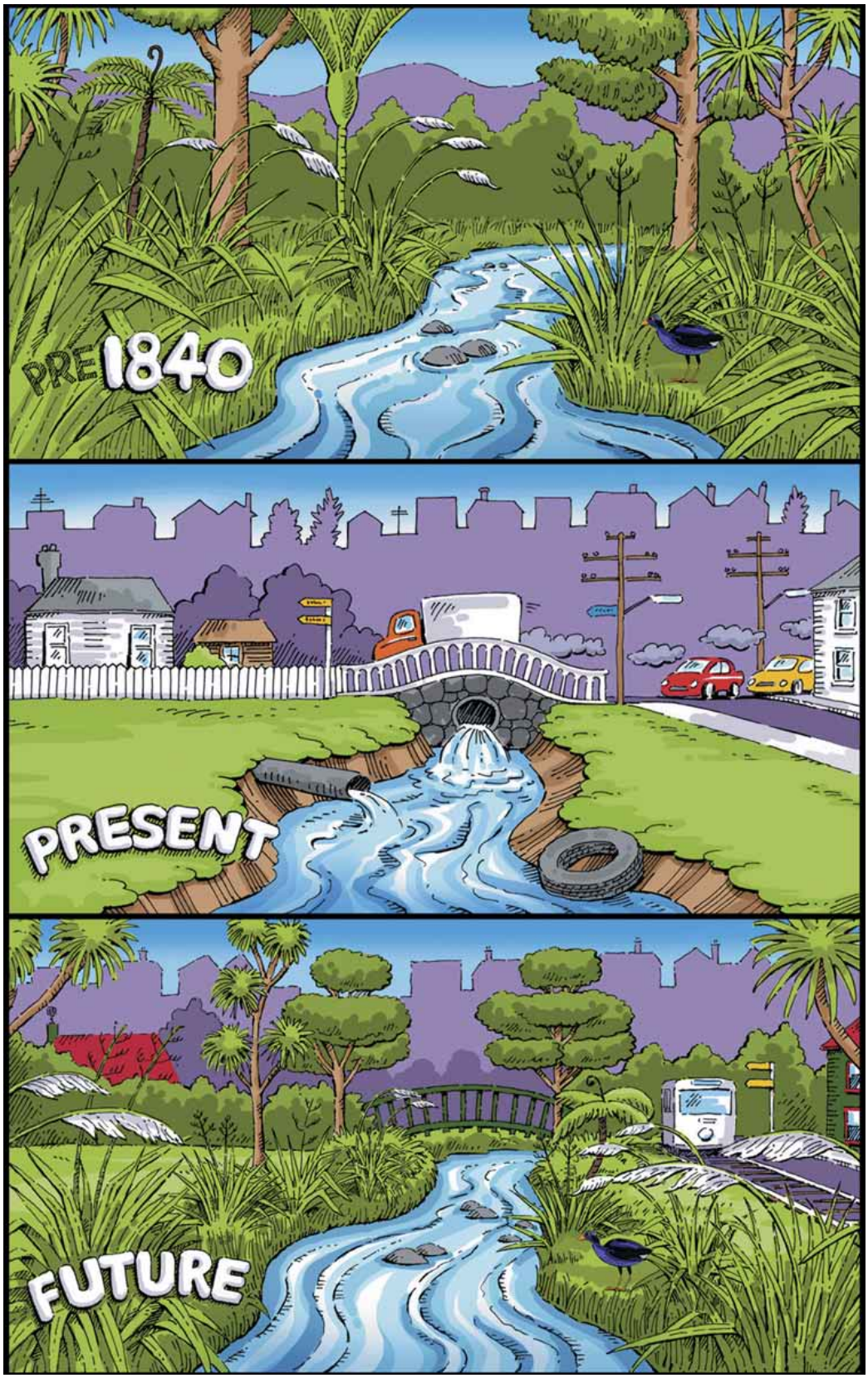
*Figure 4 Land Cover Database for Auckland Region, showing current extent of indigenous forest, scrub, pasture, urban area, wetlands etc*

Source: Landcover Database for Auckland Region. Terralink Ltd. (2000)

*This diagram has been moved to* ***Part 1 – Appendix A****, which may be down loaded as a separate file*

*Figure 5 Riparian zones: past present and future*

Source: Tim Lovegrove, ARC



2000). A similar study in the Wairoa catchment found that 95% of these mapped streams were perennial (Boffa Miskell, 2000).

The waterways of the Auckland Region are dominated by small (by national standards) rivers and numerous small streams, seven small lakes and a number of dune lakes, especially in the west of the region on the Awhitu and Kaipara peninsulas. Little information is currently available on the extent of ephemeral streams (those that do not have flow or stable pools all year round) and associated headwater wetlands in the Region. Their intrinsic value and their beneficial contributions to the hydrological, water quality and ecological conditions of perennial streams downstream are poorly understood.

Good management of riparian vegetation thus needs a comprehensive catchment approach based on ephemeral and perennial elements of the stream network. For example, connecting up patches of terrestrial vegetation by riparian planting along the full stream network improves the ecological function of both the plants and the streams. These beneficial effects progressively accumulate from ephemeral headwaters to downstream reaches.

The terrestrial and aquatic functions of riparian zones, while difficult to quantify, add further support to efforts to manage riparian areas, especially when the precautionary principle is applied.

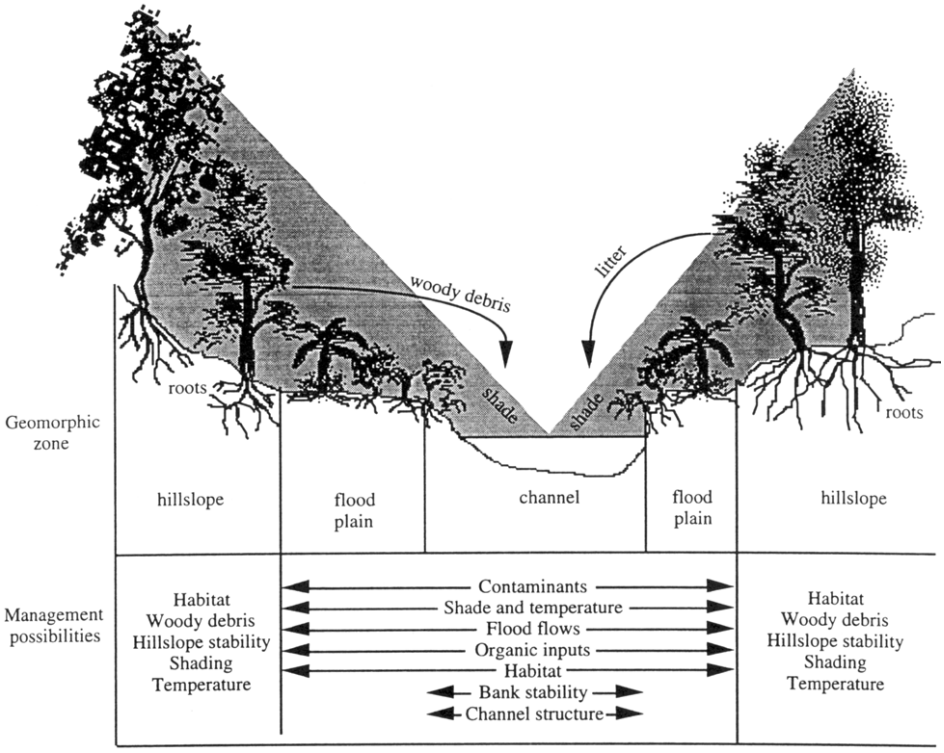
*Plate 5 Enhancement of riparian zone*
Source: Tim Lovegrove, ARC

*Plate 6 Restoration of riparian zone*

Source: Tim Lovegrove, ARC

*Figure 6 Conceptual diagram of a stream and its riparian area showing geomorphic zones and management possibilities*

Source: Managing Riparian Zones NIWA/Department of Conservation Guidelines July 1995, volume 1 page 7



## 2.0 What is a riparian zone?

**Preview**

This section of the Strategy looks at:

- a definition of 'riparian zone' for the purposes of this Strategy
- a review of overseas and New Zealand scientific literature about the benefits of riparian zones
- the width of riparian zones
- native and exotic species
- implications for this Strategy and Guideline

The term riparian zone has no single accepted scientific definition, but is often used informally to signify:

*"the strip of land bordering a stream, lake or estuarine/ coastal zone. It is the transitional zone between land and water. It characteristically possesses soils, which are wet and sometimes inundated, is commonly found on floodplains and near the bottom of hill slopes adjoining streams.*

*'The riparian zone is the streamside area that significantly interacts with the stream through a variety of processes that affect water quantity and quality and determine key ecological relationships of both the aquatic and terrestrial systems." (pers comm K.J Collier, 2000.)*

When applied to streams, as is most commonly done, the term a riparian zone usually refers to an area extending back from each bank up the neighbouring valley-side slopes. Channels and wetlands in waterways are not strictly included, though wetlands often do occur in riparian zones beside the stream or river's primary flow path, especially in lower reaches of streams and on floodplains.

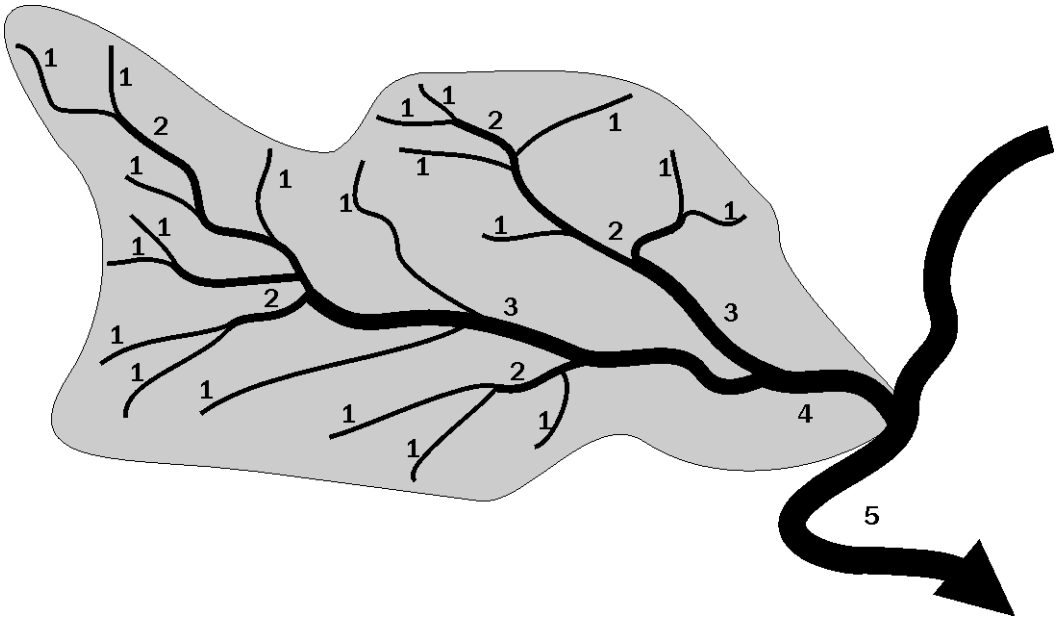
### 2.1 A definition for the purposes of this Strategy

This Strategy and the accompanying Guideline and Planting Guide only address riparian zones along perennial (permanent) freshwater streams in the Auckland region, as shown in the conceptual diagram in Figure 6. It applies from the point where tidal influence ceases to affect salinity up to where the stream and its tributaries have ephemeral (intermittent) flow.

The Region's perennial streams generally comprise first, second and third order perennial streams and stable pools in the Auckland Region. Stream order is based upon smaller streams draining into larger ones. First order streams are catchment headwater streams. They are generally the smallest streams and flow can be perennial or ephemeral. Second order streams are those formed by the junction of two second order streams. A third order stream is formed by the junction of two second order streams. Thus fourth and fifth order streams are formed in the same way. A schematic representation of stream order is shown in Figure 7.

*Figure 7 Hypothetical catchment showing stream order*

Source: Low Impact design manual for the Auckland Region TP 124 April 2000. (Fig 2-9). Based on the Strahler method.



For the purposes of this Strategy, therefore, all streams drawn on 1:50,000 scale topographic maps are considered perennial and are thus covered by the Strategy.

However, the Strategy also recognises the aquatic values of ephemeral streams and wetlands, because they are directly connected to permanently flowing streams. Consequently, the ARC encourages the protection, enhancement and restoration of riparian vegetation along ephemeral streams and wetlands wherever possible.

## 2.2 Scientific background and selected literature review

The scientific principles of riparian zone management are well established in New Zealand and internationally. This section summarises some of the key findings on which this Strategy and Guideline are based.

### *Key overseas findings*

The most comprehensive international review of buffer zone research and implementation is the proceedings of the August 1996 United Kingdom conference entitled Buffer zones: their processes and potential in water protection. The proceedings bring together a wide range of work on the positive role of riparian ('buffer') zones in controlling sediments and contaminants in surface waters, and the adverse effects on riparian zones of a wide range of land uses and agricultural practices. Restoring riparian buffer zones was seen as a beneficial element of catchment management planning. (Haycock, Burt, Goulding, Pinoy, 1996)

However, although there is general agreement internationally that riparian zone management is an excellent tool for sustainable resource management, many of the researchers at the conference reported on the practical difficulties of riparian protection and restoration, with land ownership issues and the width of the riparian zone being the most common problems world-wide.

### *Key New Zealand work*

**Department of Conservation - NIWA Guideline 1995**

In New Zealand a considerable amount of riparian research was carried out by the National Institute of Water and Atmospheric Research (NIWA) and the Department of Conservation (DoC) in the early 1990s. Much of this work contributed to the preparation of a two-volume 1995 publication, *Managing Riparian Zones* (Collier et al 1995). Each volume contains a list of references and an 'important reading kit', a list of publications essential to the understanding and application of specific guidelines.

Volume 1, Concepts, describes the purpose of the guidelines as being 'to provide information on how to improve the management of riparian zones along streams and rivers in modified and developed landscapes'.

Volume 2, Guidelines, describes a number of resource management problems associated with the loss of riparian zones. It describes how to plan a riparian management scheme and identifies problems that can be addressed by riparian management. It contains guidelines on key riparian-related environmental topics such as:

- maintaining stream bank stability
- reducing contaminant and nitrate inputs to streams
- maintaining suitable light and temperature conditions in streams
- maintaining carbon inputs to streams
- attenuating flooding
- providing riparian and aquatic habitat

Each guideline topic in Volume 2 sets objectives, refers to relevant literature such as publications included in the reading kit and gives cross-references to related guidelines. It outlines how to determine the scale of the problem and the plant species most likely to address the problem.

Volume 2 includes a section on justification and assumptions as well as information on side effects and limitations of riparian zones and an assessment of the likelihood that the recommended treatment will work. It also has a list of native and exotic plant species that can be used in riparian management, and includes information on suitability, size at maturity, growth rates and comments on uses and tolerances of the plants listed, although it is recommended that local advice be sought from a nursery. This guideline accordingly includes information on riparian management and a Planting Guide specifically for the Auckland region.

This guideline is the key reference for these guidelines. Other riparian management-related research conducted after 1995 is summarised in ARC Working Report No **90**.

## 2.3 Width of sustainable riparian zones

What constitutes a sustainable riparian zone - that is, one in which desirable plants and faunal communities can reproduce themselves and promote self-sustaining desirable aquatic communities in the long term - is a complex question of water quality and habitat. The major influences on water quality and habitat include stability, shade, nitrate, carbon, flow and temperature (NIWA/DoC, 1995).

NIWA* and Wildlife** Consultants Ltd (Parkyn*, Shaw** and Eades**, August 2000) have evaluated the following four key areas of width-related research carried out since the 1995 guidelines were prepared:

- the potential for sustainability, natural succession, and low maintenance through weed control in riparian zones
- definition of the links between riparian buffer zones and aquatic functions and habitats
- the relevance of the minimum buffer width to streams in the Auckland region with regard to stream size
- how a management approach using a minimum riparian width relates to the findings of the 1995 NIWA/DoC guidelines

Their findings are summarised below.

Riparian zones contribute to a wide variety of stream management functions. Parkyn et al 2000 evaluated the width of the riparian zone that will provide these functions over a variety of streams based on sustainability of indigenous vegetation. This evaluation looked at the width of the riparian zone necessary to support a buffer zone that is self seeding and able to minimise weed growth. A literature review confirmed there was a paucity of research on riparian zone width, although there is some information on 'edge' effects. Edge effects occur along the boundary of a riparian zone and include penetration of light, weeds and plant and animal pests, plant reproduction and effects on movement of birds and other fauna for feeding and reproduction.

Based on a site visit to selected Auckland Regional Parks, Parkyn et al (2000) made three recommendations for riparian zone width:

1. 5-6m wide buffers: these are recommended for small waterways or where there are no other options for wider planting. These buffers are so narrow that edge effects mean natural regeneration of indigenous species is limited and they need on-going maintenance to keep them weed free
2. 10m wide buffers: these allow for indigenous vegetation succession and should result in a relatively low-maintenance riparian zone. Edge effects mean that the outer 1-2 metres of the buffer is likely to suffer weed infestations, and these weeds would spread to the interior of the riparian zone wherever canopy gaps occurred
3. 15-20m or wider: buffers of this width are thought to be self-sustaining for indigenous vegetation, and should be required on large waterways

Riparian management relevant to land use and stream types in the region has been discussed with respect to a greater than 10m buffer in Parkyn et al 2000. Some limitations of indigenous vegetation buffers of even 10-20m width include:

- control of shade tolerant weeds along edges may always be necessary
- success depends on establishing closed canopy cover early
- shading of pre-existing groundcover plants by indigenous tree species may release sediments held in the banks of streams
- a grass buffer may be better than tree species as a filter for sediment and nutrients
- microclimate conditions comparable to those in forest interiors may not be achieved with buffers less than 40m
- headwater wetlands should be protected by fencing from stock and planted with wetland species rather than trees so that the wetland is not shaded or dried out

A buffer width of more than 10m (15 m preferred) of a range of riparian vegetation will achieve most of the identified aquatic benefits, such as shade, food supply and habitat. If water quality improvement alone is the main objective, however, especially the reduction of nutrient and sediment runoff to waterways, then a grass buffer zone is an effective option.

**In light of the above, a 10m minimum buffer width is therefore recommended as a general guideline for the purposes of this Strategy and Guideline, with narrower or wider options being considered appropriate as indicated by site constraints or opportunities.**

## 2.4 Native and exotic riparian plantings

The ARC advocates eco-sourced native vegetation for all replacement and restoration planting in the Auckland Region for their overall wide range of beneficial environmental effects. Information is available from ARC Parks on seed collection and propagation methods. A Council booklet, *Native Forest and Wetlands* (ARC 1998), describes how to care for and protect natural areas and a practical guide to restoration of forest and wetlands in the Auckland Region will be available from late 2001. ARC Biosecurity can advise on plant maintenance and pest control for both native and exotic vegetation, while Regional Parks will continue to play a role in seed collection, germination and propagation of native plants for use by Care Groups and commercial nurseries.

The main exception to this policy is the use of poplars to control soil erosion, because their rapid growth makes them very effective in stabilising erosion-prone areas. In recent times around 30,000 native trees have been planted each year in the Auckland region, mainly for enhancement of the terrestrial environment and soil erosion control. An estimated 10% of these plantings are for riparian enhancement or restoration. In some cases poplars have been used on stream banks, because they grow fast and have a good root mass that helps to stabilise the stream bank. However, crack willows and other brittle varieties of willow are a threat to stream flows, accentuate flooding and reduce biodiversity in wetlands, and are not recommended for use in or near waterways.

The protection of existing exotics is supported if they are non-invasive and have positive environmental values, such as landscape and amenity value. In many cases these existing trees also provide food and habitat for a wide range of birds and terrestrial species. Nevertheless, a preferred long-term management strategy for beneficial exotic species in riparian zones would be to under-plant and replace with natives in a natural succession.

In summary, this Riparian Strategy and Guideline recommends that native vegetation in the Auckland Region should be protected, enhanced or restored.

## 2.5 Effects of livestock on streams and potential benefits of riparian management

NIWA (April 2001) have researched the effects of livestock on streams and their riparian margins, they conclude that:

- Remnant native vegetation in the riparian zone has further degraded from livestock access to the stream.
- This has lead to reduced shade and shelter, resulting in drying of soils in riparian zones.
- These compacted and damaged soils have reduced infiltration capacity and reduced contaminant trapping capacity.
- Destabilised stream banks and channels result in erosion, streambed siltation and water turbidity.
- Results in reduced water quality from sediment inputs, overland flow of nutrients and microbial contamination from animal waste.
- This leads to degraded stream habitat and reduced stream health resulting from the above damages as indicated by changed composition of aquatic invertebrate animals, and reduced abundance of certain native fish.

The investigation concludes that restricting livestock access to streams and riparian zones will mitigate much of the above damage. Permanent exclusion of stock by fencing is the obvious management approach. Other options include temporary fencing, bridging of farm raceways, and provision of off-stream water and shade. The extent of the riparian recovery depends on factors such as type of livestock and riparian management, width of the buffer zone. Following restriction of stock contaminant filtering will recover quickly whereas channel stabilisation may take decades to recover.

## 2.6 Implications of the research for this Strategy and Guideline

Both local and international attempts at riparian zone management and restoration have encountered problems with:

- land ownership
- width of buffer strips and riparian zones
- whether native plants should be preferred to exotics

This Strategy, Guideline and Planting Guide attempt to overcome these issues by:

- helping to address land ownership problems by promoting voluntary measures, including community-based initiatives, and providing support and information to encourage rather than require riparian zone restoration, protection or enhancement, while using mandatory options when converting land for more intensive developments
- recommending a standard 10m **minimum** width for sustainable riparian zones that are required as part of mandatory riparian zone management measures (NIWA, August 2000)
- promoting voluntary measures and information that encourages people to use the standard minimum width
- discussing the relative merits of native versus exotic plants so that people can make informed choices.

## 3.0 Review of the benefits of riparian zones

**Preview**

This section of the Strategy looks at the benefits of riparian zones in terms of:

- terrestrial environments
- aquatic environment: physical, geomorphic and hydraulic characteristics
- biological – water quality and habitat characteristics
- resource management:-sustainability and biodiversity

The riparian zone is an important zone for land and water interactions, because most runoff must pass over or through the soil and vegetation of this zone before it can reach the adjacent water body. It can thus have a critical effect on water quality, especially light and temperature, as well as flows.

The main significance of the riparian zone is its action as a buffer to moderate the adverse effects of land uses and land management on the stream, lake or estuarine ecosystems to which a catchment drains. The buffer effect also works in the reverse direction, protecting the land from damage caused by floods by reducing water velocities when flows overtop banks.

Riparian zones, including grassy buffer zones for nutrient and sediment removal along their landward margins, thus have an important role to play in managing water and ecological resources. Well-managed riparian zones are important for the reasons summarised in Table 2.

The influence of riparian zones is much larger than would be expected from their size relative to the rest of the catchment, so an understanding of how they operate is very important when designing riparian management strategies to suit a particular locality.

Restoration of instream ecological values and improvement of water quality depends primarily on effective management of riparian vegetation. By careful selection of the mix of species planted within a riparian community, it is possible to beneficially modify light, temperature, nutrient and sediment regimes, channel and bank stability, carbon inputs and habitat for terrestrial species (NIWA/DoC, 1995).

Temperature, river flows, streambed substrates, food resources, nutrient and sediment regimes are influenced by conditions both on-site and upstream (NIWA/DoC, 1995). Inputs of nutrients (nitrogen and phosphorus), suspended solids, pesticides and microbes occur unevenly along a river system and within any reach. Consequently, these inputs are more quickly and effectively managed by targeted remedial measures at important source areas within the catchment rather than by adopting long term catchment-wide control measures (NIWA/DoC, 1995).

Changes to riparian management alongside small streams will generally exert a larger influence on stream functioning than they will alongside large lowland rivers. Lowland river management through riparian planting largely entails management of smaller streams further upstream (NIWA/DoC, 1995). These principles are vital to the design of riparian management strategies for catchments.

Riparian wetlands are believed to play important roles in regulating runoff, removing nutrients, providing carbon and increasing habitat diversity. Most nitrate in groundwater passing through wet, organic rich riparian seeps is removed by denitrification (NIWA/DoC, 1995).

The beneficial results of riparian zone management on streams are often not immediate and may take several years to become evident. Stream and channel shape in particular will probably take considerably longer to reach a new equilibrium (NIWA, 1995), and this may result in some increased sediment concentrations in the medium term until it is reached.

*Table 2 Summary: Ecological Benefits of Riparian Zones*

Source: Adapted from NIWA/DoC Managing Riparian Zones, 1995

| Riparian Zone Function | Potential Benefits |
|---|---|
| **Terrestrial Environment** | |
| Increases habitat area in the Region | Provides habitat and food for aquatic, bird and terrestrial species |
| Links riparian and terrestrial vegetation | Provides ecological corridors for birds and wildlife |
| Improves aesthetic and landscape values | Provides amenity and recreational opportunities, access may be limited by fencing |
| **Aquatic environment: physical, geomorphic and hydraulic characteristics** | |
| Improved bank stability, tree roots protect banks from erosion and undercutting * | Reduces nutrient, sediments and pathogen inputs to streams. |
| Buffers channels from localised changes in morphology * | Reduces physical damage to in-stream habitats from flooding and erosion and consequential deposition of eroded material along |
| Stabilised channel shape * | Promoting natural hydraulic regimes by reducing flood peaks, retaining water in the catchment, slowing transmission of peaks downstream, increasing base flows |
| **Biological – water quality and habitat characteristics** | |
| Riparian trees and shrubs provide shade for streams | Maintains lower summer maximum temperatures, enhances dissolved oxygen and reduces nuisance growths of aquatic vegetation and develops "clean water" invertebrate communities |
| Provide inputs of nutrients and food for native fish and invertebrate species | Riparian trees and shrubs supply carbon (food) to streams in the form of leaf litter, insects and micro-organisms |
| Provide woody debris in stream channels | Increases habitat and refuges for a wide range of micro-organisms, invertebrates and fish species |
| Buffers input of nutrients, soil, microbes and pesticides in overland flow | Filters pollutants from surface runoff before it enters streams |
| Improves fish passage | Overhanging vegetation protects migrating fish from predators and light |
| Increase bank side and habitat diversity | Links the upland, lowland, freshwater and coastal habitats |
| Increases the quality of streams and wetlands in the Region | Wetlands can improve water quality and increase food supply to streams |
| Preserves the life supporting capacity of the waterway | Riparian zones can be used as mitigation against land use change |
| Careful selection of riparian plants provide long-term benefits to the aquatic and terrestrial environment | Riparian zones are most effective on small stream and tributaries of large rivers, they influence large areas of catchment relative to their size |

* Riparian management may initially cause some bankside erosion and channel widening, these matters are currently being researched.

# 4.0 A way forward for restoring Auckland's riparian zones

**Preview**

This section of the Strategy looks at:

- an approach to riparian zone management: maintain, enhance and restore
- some priorities: rural areas, new developments, existing urban areas and parks

It is impossible to turn the clock back: we cannot restore 100% of the freshwater and riparian habitat the region has lost. However, it is possible to agree on an achievable goal that achieves reasonable environmental benefit for a reasonable cost.

Although it is neither possible nor necessary to return to pre-human conditions, this guideline aims towards a feasible goal for riparian zone management, that

- is achievable and affordable by the regional community
- will achieve sustainable resource management objectives

An assumed 15 metres of riparian zone (NIWA 2000) along both banks of the Region's 10,000 km of perennial streams (including in the Hunua and Waitakere Ranges) would occupy 300 square km, equivalent to 6.7% of the Region's land area. A 5m riparian margin on either side of the stream would be equivalent to 2.2% and a 10m margin would to 4.4% of the Region's area. It is considered that 6.7% is goal for a regional total of riparian cover because:

- it will never be possible to restore riparian cover in catchments where the whole stream system has already been piped
- in some catchments a lesser width of riparian margin will only be possible because of physical factors such as very steep adjoining slopes, adjacent buildings or other constraints common in developed catchments
- the cost of full riparian protection or restoration by many individual land owners would be prohibitive, so they will be encouraged to develop very long term plans and to implement only the most beneficial options in the short to medium term (for example planting areas that target key runoff sources or link key fragments of riparian vegetation)

This Strategy therefore provides a range of low cost alternative approaches to riparian management to help land owners meet their identified resource management objectives.

Rather than putting a numerical goal in terms of regional coverage of riparian areas, therefore, the Strategy therefore instead highlights areas most likely to deliver beneficial outcomes, in the following major land use categories:

- rural areas
- greenfield developments
- existing urban areas
- regional and other parks

Within each of these areas, the management goal of this Strategy is to:

- **retain** existing riparian zones in good condition
- **enhance** existing riparian zones in poor condition
- **restore** riparian zones in areas where they do not currently exist

## 4.1 Rural areas

Voluntary measures will be the main way of promoting riparian zone management in rural areas. Many rural land owners have already done a lot of work in revegetating gullies and protecting stream banks from erosion, and this work will be encouraged as much as possible by education, promotion, training and supporting community initiatives such as LandCare and Trees for Survival.

## 4.2 Greenfield developments

Mandatory measures to retain, enhance and restore riparian zones can readily be applied as part of resource consent conditions applied to development works that convert rural into urban land uses. Riparian management can be required under regional and district council polices, plans, rules and resource consent conditions. Landowners affected by these policies and rules and those involved in the riparian industry will be invited to attend ARC Riparian Management Training Programmes.

## 4.3 Existing urban areas

Voluntary initiatives are already under way in some urban areas to retain, enhance and restore riparian zones. The ARC will encourage and support such initiatives as much

as possible, mainly through working with city and district councils and community groups by educational means and inviting participation in the ARC Training Programme.

### 4.4 Regional and other parks

The ARC has been actively restoring riparian zone vegetation throughout its network of regional parks for many years. This provides a unique opportunity to demonstrate plantings of many different ages and their beneficial effects on terrestrial and aquatic ecology. Such sites provide wonderful educational and scientific opportunities, and this work will be ongoing. The Regional Parks will be used as case studies for the ARC Training Programme. The ARC will also promote and support similar initiatives in parks owned by other organisations such as city and district councils and the Department of Conservation.

### 4.5 What is the Strategy's timeframe?

Because the Strategy envisages a mix of voluntary and long range planning tools, it is an on-going programme that will take years to decades to achieve its purpose.

The ARC will review the Strategy within five years of the implementation date and every five years thereafter. The review will include representative monitoring of riparian programmes in order to identify and evaluate progress and future needs of riparian zone management in the Auckland Region.

## 5.0 Why do we need a Strategy and Guideline?

**Preview**

This section of the Strategy looks at:

- why the Auckland Region and the ARC need an integrated approach to managing riparian zones
- benefits to the landowners of riparian planting

### 5.1 The need for an integrated regional approach

Riparian management is one of the tools for achieving sustainable environmental outcomes but the Regional Council cannot implement riparian management alone. Because regional, city and district councils share responsibilities under the Resource Management Act, a shared regional vision and strategy for achieving it is needed.

The individual agencies all have policies supporting riparian management and regulatory responsibilities to minimise adverse environmental effects. An overall strategy would provide:

- links to external and internal drivers for a co-ordinated approach
- a clear picture of where we want to go: that is, a realistic and achievable outcome for riparian management in the Region
- a consistent method of getting there which enables all parties to work together with agreed priorities and time frames

This Strategy aims to:

- define regional visions and management objectives
- clarify roles and responsibilities
- provide guidance and support for local solutions

Many current initiatives in the region have a bearing on riparian zone management. Developing a co-ordinated and consistent approach would yield major benefits to all of them, while also providing more impetus for riparian zone management itself. There are strong drivers for improved co-ordination and consistency both within and beyond the Council and other stakeholders.

## 5.2 Regional drivers for co-ordinated riparian zone management

External drivers for councils in the region to take a more co-ordinated approach to riparian zone management include:

- the Resource Management Act, which promotes sustainable and effects-based resource management
- the national Biodiversity Strategy
- the need for consistency, to ensure that the many existing related activities take a consistent approach, for example Waitakere City Council's Greenprint project, Trees for Survival, LandCare Groups, WaiCare and so on, as well as people and organisations required to implement riparian zone management as part of statutory processes. A regional strategy enables a co-ordinated approach within which all these initiatives can be pursued in a more cost-effective way towards agreed goals

## 5.3 Internal consistency for the Regional Council

There is a wide range of initiatives within the Council with implications for riparian zones. There is thus a need to ensure that they are co-ordinated and consistent with each other.

Some of the Council's current initiatives that affect riparian management are:

- the low impact development guideline (ARC Technical Publication 124, April 2000)
- the erosion and sediment control guidelines for land disturbing activities ( ARC Technical Publication 90, published 1999)
- guidelines for urban stormwater management including ARC Technical Publication 10, published 1992, and its revision
- the natural heritage restoration strategy
- the biosecurity strategy
- various regional park management plans with riparian restoration goals

## 5.4 Drivers for landowners

Drivers for rural and urban landowners to carry out riparian zone management include:

- enhanced property value
- enhanced recreational opportunities, such as walkways and cycle ways
- habitat restoration, for example more freshwater and bird life
- improved amenity and landscape quality
- the need to address an identified problem such as stream bank erosion
- good animal husbandry, for example shelter for stock
- the example of others, where beneficial results are seen on other properties
- the beneficial results portrayed by education about and promotion of the benefits of riparian zone management

A more co-ordinated and consistent approach by councils and other stakeholders in the region would enhance the effectiveness of all these drivers for private landowners to retain, enhance and restore riparian zones. This is being achieved by review of District Plans and requirements of resource consent conditions.

# 6.0 Vision and strategic objectives

Restoration of native riparian forest alongside developed streams aims to increase habitat diversity and the diversity of native plant and animal communities, in order to contribute to more sustainable development. However, in order to be consistent and cost-effective, a formal Strategy to promote riparian zone management needs a clear vision and objectives. These need the agreement of both the Auckland Regional Council and other stakeholders in the Region.

A vision and objectives for the Auckland Regional Council's riparian zone management Strategy are proposed below. They are consistent with the Auckland Regional Policy Statement (ARC 1999).

**Vision**

**Auckland's freshwater aquatic resources adversely affected by land development are rehabilitated to foster a richer, more varied landscape where stream headwaters are linked to estuaries and the sea, in which communities exist in a sustainable relationship with productive land and healthy aquatic environments.**

***Strategic objectives for riparian zone management in the Auckland Region***

1. To safeguard the life - supporting capacity of water and aquatic ecosystems from the adverse effects of subdivision, use and development.
2. To enable people and communities to use and develop freshwater resources to provide for their social, economic and cultural well-being.
3. To promote conservation values by promoting riparian zones which maintain or enhance the natural functioning of the adjacent sea, river, or lake, and also water quality, aquatic habitats and natural values, and which mitigate natural hazards and provide detailed guidance on how to do it.
4. To focus on retaining and enhancing riparian zones where they exist, and restoring them where they do not but could exist, in rural areas, greenfield developments, existing urban areas, regional and other parks and areas where other initiatives make them desirable.
5. To improve public understanding of the importance of riparian vegetation in catchment ecosystems, and, coupled with well defined goals and environmental values, to lead to a widespread acceptance of riparian zone management as a 'tool' for total catchment management.
6. To encourage a wide range of land owners and/or community interests to form LandCare Groups or catchment associations and initiate their own best management practices with the help of this Guideline.
7. To monitor and report on progress in retaining, enhancing and restoring riparian zones in numerical terms using widely accepted indicators. (numbers, areas and observable benefits, under development by MfE ).

## 7.0 Who should use the Guideline and Planting Guide?

**Preview**

This section of the Strategy looks at:

- who should use the Strategy, Guideline and Planting Guide
- the benefits they will enjoy as a result

The Guideline is a non-statutory resource management instrument for use by:

- individual land owners
- Tangata whenua
- land developers
- the professionals: consultants, landscape architects and contractors, planning, engineering and environmental consultants
- environmental protection and other community groups
- planning and regulatory staff in the Auckland Regional Council and the region's seven city and district councils

Riparian planting by these parties will confer the environmental benefits summarised in Table 2, but there are other specific benefits for all participants. These additional benefits are summarised below:

***Individual land owners***

Many individual land owners, both rural and urban, wish to enhance the attractiveness and habitat value of their property with plantings. The Guideline and Planting Guide will help them plan and care for these in a way that benefits aquatic and terrestrial habitat as well as scenic appeal.

*Individual land owners can use this Guideline to:*

- have input to regional and district plans and consent applications, as well as managing riparian zones on their own land
- enhance the scenic appeal and wildlife value of their property

***Tangata whenua***

Riparian zones offer a multifaceted tool for meeting the integrated resource management goals of Tangata whenua. They bring together land and water management

*Tangata whenua can use this Guideline to:*

- have input to regional and district plans and consent applications, as well as managing riparian zones on their own land
- enhance the scenic appeal and wildlife value of their property

***Developers***

The Auckland Regional Council's low impact development guidelines promote the recognition and enhancement of natural values on land to be developed and their incorporation into attractive, sustainable developments. Developers will find it a lot easier to comply with these requirements if they use this riparian Guideline and Planting Guide to maintain or restore riparian zones as part of their development

*Developers can use this Guideline to:*

- have input to regional and district plans and consent applications, as well as managing riparian zones on their own land
- help them comply with low impact development requirements
- add value to their developments

***The professionals***

The Auckland Regional Council will work with private sector professionals to help them use the Guideline and Planting Guide, including:

- landscape architects and landscape gardeners
- engineers and contractors
- planners
- terrestrial and freshwater ecologists

These people have an important role to play in incorporating riparian zones into urban planning, design and development in ways that meet environmental, ecological and financial objectives for all stakeholders.

*Development professionals can use this Guideline* to plan and design new urban developments and services that:

- have input to regional and district plans and consent applications.
- mitigate the adverse effects of development
- help restore lost habitat as part of sustainable developments

***Environmental Protection and Community groups***

Any local environmental group or community could form a group to care for or restore riparian zones on their own land and/or that of other people, while existing organisations such as LandCare, StreamCare and WaiCare groups and Trees for Survival will also find the Strategy, Guideline and Planting Guide helpful in meeting their own goals. The Guideline gives advice on working with situations of multiple land ownership.

*Environmental and Community groups can use this Guideline* to plan the management of existing and new riparian zones:

- have input to regional and district plans and consent applications
- on public land
- on private land
- on land with many owners

***City and district councils***

Councils can both promote and require care, enhancement or restoration of riparian zones through their district planning and resource consent processes. In planning the location and broad layout of urban areas, they can use riparian zones to meet a wide range of sustainable resource management goals.

*Councils can use this Strategy and Guideline to*:

- have input and be consistent with regional plans
- plan for new development and assess development applications
- identify opportunities to integrate different riparian zones with each other and existing stands of plants

***The Auckland Regional Council and other councils in the region***

Like the city and district councils, the Regional Council can use a mix of policy, regulatory and voluntary tools to promote riparian zones throughout the region. The Council will actively promote the Strategy, Guideline and Planting Guide by running training workshops and other educational means.

The Council can also take advantage of the Strategy to bring together the goals of several other related Council strategies, including stormwater and flood management, water quality, water resources, terrestrial and aquatic habitat and biodiversity.

*Staff of the Auckland Regional Council can use this Strategy, Guideline and Planting Guide to*:

- have input to and be consistent with district plans.
- promote and specify riparian zones
- meet the goals of related programmes both within and outside the Council

## 8.0 Implementing the Strategy

**Preview**

Sustained commitment is needed to ensure continued progress towards the Strategy's Goals. This section discusses how the Strategy will be:

- promoted
- implemented
- monitored and reviewed for ongoing effectiveness

It also looks at the training available to help those who want or must implement riparian zone management.

Effective implementation of the Riparian Zone Management Strategy requires a long term commitment of time and resources from the Auckland Regional Council and other key stakeholders.

Key elements of a long term implementation programme include:

- ongoing promotion of the Strategy, Guideline and Planting Guide.
- regular training courses on how to use the Guideline and Planting Guide.
- ongoing monitoring and review of the Strategy, Guideline and Planting Guide.

### 8.1 Promotion

Ongoing promotion of the Strategy, Guideline and Planting Guide has two key areas of focus:

- regulatory
- voluntary

The Auckland Regional Council will promote and implement regulatory means of requiring riparian zone management by:

- making submissions on district plans, structure plans and consent applications
- attaching appropriate conditions to resource consents

The Council will promote voluntary riparian zone management by:

- promoting the concept of riparian zone management and the availability of the Strategy, Guideline and Planting Guide by a range of means including the Council's web site, media releases, shows and displays, newsletters, leaflets, community liaison, public talks and presentations to relevant groups such as the earthworks industry, planners and so on
- supporting local initiatives and groups, such as LandCare, Trees for Survival and other relevant community initiatives, opportunities for funding are set out in section 1.4 of the Guideline.
- actively promoting the availability of training courses to key target audiences

### 8.2 Training

Training courses in how to use the Guideline and Planting Guide will be offered on an as-required basis to key stakeholders, target audiences and interested people and groups. Potential candidates include:

- relevant city and district council staff
- developers
- surveying, engineering and planning consultants
- earthworks and fencing contractors
- landscape architects and gardeners
- native plant nursery managers and staff
- LandCare and other relevant groups
- individuals known to have an interest in riparian zone management

Those attending the training will receive an attendance certificate and will be put on the mailing list of a regular newsletter.

### 8.3 Monitoring and review

Ongoing monitoring and review will focus on:

- the Strategy: progress made towards increasing the area and condition of riparian zones in the Auckland region
- the Guideline and Planting Guide: how user-friendly, up-to-date and comprehensive they are

***Strategy monitoring and review***

Regular reviews of the Strategy will evaluate progress made towards increasing the area and condition of riparian zones in the Auckland region. Tools for this will include:

- setting up a database to map native bush areas and wetlands and track the progress of all riparian retention, enhancement and restoration projects
- developing and refining a protocol for assessing the condition of riparian margins

Successes and failures will also be documented, especially reasons for success or failure of riparian zone management initiatives, in order to ensure the Strategy, Guideline and Planting Guide are effective in meeting the Auckland Regional Council's Vision, Goals and Objectives for riparian zone management.

The first step is to set measurable objectives based on the identified Vision and Goals, then to plan a programme of activities to achieve these objectives. These can then be evaluated using the 'SMARTER' model of objectives which are:

- *specific* to the programme, activity, target group, issue or goal
- *measurable*, enabling effective evaluation
- *achievable*, in terms of the size of the problem, how it is defined and known information
- *realistic*, given limitations of time and resources
- *time-bound*, to enable progress to be measured against agreed timeframes
- *endorsed* – supported by the staff, members and clients concerned
- *relevant* to the Council's functions, programmes and objectives, yielding a real benefit to staff in ease of work and work load

A system of recording activities for evaluation is also needed, and the three levels of measurement recommended by the International Committee of Public Relations Consultancies Associations (1997) are proposed for this:

- *output* – what the Council does and produces
- *out-take* – what the target audiences notice and adopt
- *outcome* – how much what is done contributes towards the identified objectives and desired environmental outcomes

The above publication outlines the format of this methodology for evaluating progress towards achieving the Strategy's vision and goals.

Criteria would include parameters such as the area of plantings, and would thus closely relate to the database noted above.

To complement this, a set of criteria for identifying ecological, hydrological and amenity benefits of planted riparian zones is also needed. Council staff will work with stakeholders to identify these criteria and develop a cost-effective monitoring regime. This will be closely related to the development of the protocol for assessing the condition of riparian margins (see above).

***Monitoring and review of the Guideline and the Planting Guide***

Regular reviews of the Guideline and Planting Guide will evaluate how user-friendly, up-to-date and comprehensive they are, with amendments being made to ensure they remain easy-to-use best practice manuals.

With time, the Guideline will also include summaries of relevant research as well as more information on local case studies and success stories.

## 8.4 Other needs

Ultimately, it is hoped to develop a guideline for the retention, enhancement and restoration of estuarine and coastal vegetation, to complement the freshwater focus of this Guideline.

The Council will also maintain a watching brief for other initiatives relevant to riparian zone management, to ensure consistency and co-ordination of effort directed towards complementary goals. Other tools such as computer-based aids to conservation and restoration will also be considered as they become available.

## References

ARC (1998), *Native Forest and Wetland. A guide to the care and protection of natural areas.*

ARC Technical Publication No 10 (1992). *Stormwater Treatment Devices Design Guideline Manual.*

ARC Technical Publication No 124 (2000). *Low Impact Design Manual for the Auckland Region.*

ARC Technical Publication No 90 (1999). *Erosion and Sediment control Guidelines for Land Disturbing Activities in the Auckland Region.*

ARC. 2001. Geographic Information System (GIS) Streams data layer. Information Services.

Auckland Regional Council (ARC), 1999. *Auckland Regional Policy Statement.*

Boffa Miskell Ltd, 1999. *Wairoa River Catchment Riparian Margins Inventory and Issues Assessment.* A Report prepared for the Auckland Regional Council.

Boffa Miskell, Ltd. 2000. *Wairoa river catchment - riparian margins, first order stream ecology.* Prepared for the ARC, Environmental Management, Auckland.

Collier, K.J., Cooper, A.B., Davies-Colley, R.J., Rutherford, J.C., Smith, C.M., and Williamson, R.B. 1995. *Managing riparian zones - a contribution to protecting New Zealand rivers and streams.* NIWA and the Department of Conservation (DOC), Wellington.

Davies-Colley, R.J., and Parkyn, S. 2001. *Effects of domestic livestock on streams and potential benefits of riparian management, issues and options in the Auckland region.* NIWA, Hamilton. Prepared for the ARC, Environmental Research, Auckland.

Haycock, N., Burt, T., Goulding, K., Pinay, G. (Eds). *Buffer Zones: Their Processes and Potential in Water Protection, Proceedings of International Converence on Buffer Zones*, September 1996. Quest Environmental. UK.

Maxted, J., B. Evans, and D. Glover. 2000. *Screening-level assessment, hydrology of 1st order streams in the Auckland region.* ARC, Environmental Research, Auckland.

O'Brien, R. 1999. *Auckland stream inventory.* National Institute of Water and Atmospheric Research (NIWA), Christchurch.

Parkyn, S., Shaw, W., Eades, P., (2000) *Review of information on riparian buffer widths necessary to support sustainable vegetation and meet aquatic functions.* NIWA, Hamilton. Prepared for ARC Environmental Research, Auckland.

Rutherford, J.C., Davies-Colley, R.J., Quinn, J.M., Cooper, A.B., 1999. *Steam Shade Towards a restoration strategy.* NIWA and the Department of Conservation, Wellington.

The International Committee of Public Relations Consultancies Associations (ICO), 1997. *How to get real value from public relations: a client guide to designing measurable communications objectives*