

Integrated Stormwater Management Guidelines for the New Zealand Roading Network

Transfund New Zealand Research Report No. 260

Integrated Stormwater Management Guidelines for the New Zealand Roding Network

B. Kouvelis & W. Armstrong (Editors)
MWH (NZ) Ltd
Wellington, New Zealand

Transfund New Zealand Research Report No. 260

ISBN 0-478-25372-9
ISSN 1174-0574

© 2004, Transfund New Zealand
PO Box 2331, Lambton Quay, Wellington, New Zealand
Telephone 64-4 473 0220; Facsimile 64-4 499 0733

Kouvelis, B., Armstrong, W. (Editors). 2004. Integrated stormwater management guidelines for the New Zealand roading network. *Transfund New Zealand Research Report No. 260*. 166pp.

MWH (NZ) Ltd, PO Box 9624, Wellington, New Zealand.

Keywords: compliance, design, drainage, environment, erosion, flooding, hydrology, legislation, maintenance, management, mitigation, monitoring, New Zealand, resource consents, Resource Management Act, run-off, sedimentation, stormwater

An Important Note for the Reader

The research detailed in this report was commissioned by Transfund New Zealand. Transfund New Zealand is a Crown entity established under the Transit New Zealand Act 1989. Its principal objective is to allocate resources to achieve a safe and efficient roading system. Each year, Transfund New Zealand invests a portion of its funds on research that contributes to this objective.

While this report is believed to be correct at the time of its preparation, Transfund New Zealand, and its employees and agents involved in its preparation and publication, cannot accept any liability for its contents or for any consequences arising from its use. People using the contents of the document, whether directly or indirectly, should apply and rely on their own skill and judgement. If necessary, they should seek appropriate legal or other expert advice in relation to their own circumstances, and to the use of this report.

The material contained in this report is the output of research and should not be construed in any way as policy adopted by Transfund New Zealand but may form the basis of future policy.

Contents

Executive Summary	9
Abstract	14
1. Introduction	15
1.1 Purpose of Guidelines	15
1.2 Meaning of “Stormwater Management”	15
1.3 Definitions & Abbreviations	16
1.3.1 Definitions	16
1.3.2 Abbreviations	20
1.4 Scope and Layout of Guidelines	20
1.5 Implementation and Outcomes Sought	22
1.6 Existing Guidelines and Standards	23
1.7 Context of Guidelines	24
1.8 National Consistency with Local Flexibility	25
1.9 Meaning of “Best Practicable Option”	25
2. Legal Framework surrounding the Management of Stormwater Run-off from Roads in New Zealand	26
2.1 Introduction	26
2.2 Overview of Legislation	28
2.2.1 Land Transport Management Act 2003	28
2.2.2 Land Transport Act 1998	29
2.2.3 Transit New Zealand Act 1989	29
2.2.4 Local Government Act 2002, 1974	29
2.2.5 Resource Management Act 1991	31
2.2.6 Land Drainage Act 1908	33
2.2.7 Soil Conservation and Rivers Control Act 1941	33
2.2.8 Other Legislation	34
2.3 Powers and Rights of Transit New Zealand and Minister of Transport in respect to Stormwater Drainage from Highways	34
2.3.1 General Powers	34
2.3.2 Drainage Works during Construction of Motorway	34
2.3.3 Ability to Enter onto Land to Construct/Maintain Ditches, Drains and Other Conduits	35
2.3.4 Power to Require Movement of Existing Structure	35
2.3.5 Common Law Rights	35
2.3.6 Private Property Agreements	35
2.3.7 Summary	35
2.4 Powers and Rights of Territorial Authorities in respect to Stormwater Drainage from Roads	35
2.4.1 General Powers	35
2.4.2 Distinction between “Public” and “Private” Drains	36
2.4.3 Territorial Authority Powers in respect of Public Drains	37
2.4.4 Territorial Authority Powers in respect of Private Drains	38
2.4.5 Common Law Rights	39
2.4.6 Private Property Agreements	39
2.4.7 Use of Public Works Act	40
2.4.8 Summary	40

Chapter 2 continued:

2.5	Compliance Obligations of Road Controlling Authorities in respect of Stormwater Drainage from Highways and Roads.....	40
2.5.1	Introduction.....	40
2.5.2	Obligations Arising from Statute Law.....	41
2.5.3	Obligations Arising from Common Law.....	42
2.5.4	Summary of Compliance Obligations.....	46
2.6	Minimising the Risk of Legal Action.....	47
3.	Regulatory and Non-Regulatory Stormwater Management Instruments.....	48
3.1	Introduction.....	48
3.1.1	Overview.....	48
3.1.2	Role of Strategic Plans.....	48
3.1.3	The Resource Management Act “Driver”.....	50
3.1.4	Role of Land Transport Programmes in Stormwater Management.....	51
3.1.5	Role of Activity/Asset Management Plans in Stormwater Management.....	52
3.2	Regulatory Methods.....	53
3.2.1	National Environmental Standards.....	53
3.2.2	Resource Management Objectives and Policies.....	53
3.2.3	Choice of Rule Categories.....	54
3.2.4	The Framing of Rules.....	56
3.2.5	Framing of Conditions on Resource Consents.....	57
3.2.6	Designations.....	59
3.2.7	Structure Plans.....	59
3.2.8	Building Consent.....	60
3.3	Non-regulatory Methods.....	60
3.3.1	Activity/Asset Management Plans.....	60
3.3.2	Integrated Catchment Management Plans.....	62
3.3.3	Code of Practice for Land Development.....	62
3.3.4	Subdivision Guidelines.....	63
3.3.5	Best Practice Engineering/Technical Guidelines.....	64
3.3.6	Adoption of SUD Techniques.....	65
3.3.7	Flood Plain Management Plans.....	67
3.3.8	Engineering Methods.....	68
4.	Gaining Resource Consents for Stormwater Management.....	69
4.1	Introduction.....	69
4.2	Activities Potentially Requiring Consents.....	69
4.3	How to Find Out What Consents are Required.....	69
4.4	The Global Consent Option.....	72
4.5	Meeting with Consent Authority.....	72
4.6	The RMA Consent Process.....	73
4.7	Consultation.....	76
4.7.1	General.....	76
4.7.2	Type and Level of Consultation.....	76
4.7.3	Phased Consultation.....	77
4.7.4	Parties to be Consulted.....	77
4.8	Preparation of Draft Assessment of Environment Effects (AEE).....	79
4.9	Phase II Consultation.....	80
4.10	Finalisation of AEE and Lodgement of Consent.....	80
4.11	Notification or Non-notification.....	81
4.12	Additional Information Requests under Section 92 of RMA.....	81

Chapter 4 continued:

4.13	Pre-hearing Meetings	82
4.14	The Hearing	82
4.15	Right of Objection.....	83
4.16	Right of Appeal.....	83
4.17	RCA Action following Gaining of Consent.....	83
5.	Environmental Effects and Mitigation Measures for Stormwater Management	85
5.1	Introduction.....	85
5.2	Flooding and Erosion Effects.....	85
5.3	Effects on Aquatic Ecosystems.....	86
5.3.1	Effects Arising from Changes to Flow Regimes and Stream Habitats.....	86
5.3.2	Effects of Structures on Fish Passage.....	88
5.3.3	Effects of Sedimentation on Aquatic Ecology.....	88
5.3.4	Chemical Contaminants in Road Run-off	89
5.3.5	Chemical Contamination of Urban Streams.....	90
5.3.6	Metal Bio-availability and Toxicity in Urban Streams.....	94
5.3.7	Contaminant Accumulation and Effects in Estuaries	95
5.4	Effects on Recreational and Amenity Values.....	99
5.5	Effects on Cultural Values	99
6.	Engineering Methods for Stormwater Management	100
6.1	Introduction.....	100
6.2	Route Selection	100
6.3	Assessment of Level of Service	106
6.4	Hydrological Assessment.....	107
6.4.1	Estimation of Design Flood (Peak Flow Rate).....	107
6.4.2	Effect of Climate Change	111
6.4.3	Stormwater Volumes.....	112
6.5	Road Surface Design.....	114
6.5.1	Introduction	114
6.5.2	Objective	114
6.5.3	Design Guide.....	114
6.5.4	Determining Water Depth on the Road Surface	114
6.6	Drainage Systems.....	115
6.6.1	Introduction	115
6.6.2	Objective	115
6.6.3	Procedure.....	115
6.6.4	Storage Design	116
6.6.5	Pipeline Design	117
6.6.6	Culvert Design.....	119
6.6.7	Open Drain Design.....	121
6.7	Surface and Subsoil Drainage Design.....	121
6.7.1	Introduction	121
6.7.2	Surface Drainage	122
6.7.3	Subsoil Drainage	123
6.7.4	Erosion and Scour Prevention	125
6.8	Stormwater Treatment System Design.....	125
6.8.1	Introduction	125
6.8.2	Objectives.....	125
6.8.3	Procedure.....	126

Chapter 6 continued

6.8.4	Overview of Treatment Methods.....	126
6.8.5	Source Control Methods.....	129
6.8.6	Top of Pipe Methods.....	133
6.8.7	End of Pipe Methods.....	134
6.8.8	Proprietary Systems.....	143
6.8.9	Sustainable Urban Drainage (SUD) Methods.....	143
6.9	Retrofitting of Stormwater Control and Treatment Systems.....	144
6.10	Erosion and Sediment Control during Construction.....	144
6.11	Maintenance of Treatment Devices and Conveyance Structures.....	146
6.12	Life-Cycle Costing Considerations.....	147
7.	Bibliography	155
7.1	Legal Framework Surrounding the Management of Stormwater Run-off from Roads in New Zealand.....	155
7.2	Regulatory and Non-regulatory Stormwater Management Instruments.....	155
7.3	Gaining Resource Consents for Stormwater Management.....	158
7.4	Environmental Effects and Mitigation Measures for Stormwater Management.....	159
7.5	Engineering Methods for Stormwater Management.....	162
7.6	Relevant Conferences and Workshops.....	166

Executive Summary

Introduction

These Guidelines for integrated stormwater management provide guidance on a range of issues relating to the management of stormwater run-off from state highways and local roads in New Zealand, including:

- The legal framework within which stormwater management takes place;
- The management framework (agency responsibilities and management tools);
- The gaining of resource consents for stormwater management activities;
- Environmental effects and mitigation measures;
- Best practice engineering methods.

The Guidelines have been prepared (in 2003-2004) with the primary aim of assisting road controlling authorities (RCAs) to come to grips with the sometimes complex issues surrounding the matters referred to above, and the interplay between them.

In addition to road designers, engineers and managers, it is anticipated that the Guidelines will be of interest and use to a number of other parties, including roading contractors, resource management agencies (regional councils, territorial local authorities), stormwater asset managers, consultants, iwi, environmental groups, and the general public.

Scope and Layout of Guidelines

The Guidelines are divided into the following chapters:

Chapter 1 sets out the purpose of the Guidelines, the definition adopted for “stormwater management”, and the outcomes sought. It also discusses various contextual issues surrounding the drive towards more sustainable methods of stormwater management and the key issue of what constitutes “best practice” in a given situation.

Chapter 2 summarises the legal framework surrounding the management of stormwater run-off from highways and roads in New Zealand and identifies key agency responsibilities, rights and obligations.

Chapter 3 outlines the management framework for managing stormwater run-off in New Zealand (including run-off from roads), focusing on the regulatory and non-regulatory methods that are available to the various agencies with stormwater management responsibilities. Some guidance is provided to regional and district councils in relation to the framing of objectives, policies and rules for the management of stormwater run-off from roads. The purpose of the chapter is to establish a context for the stormwater management activities undertaken by RCAs.

Chapter 4 summarises the process for gaining resource consents for stormwater management activities, including the identification of consent requirements, interaction with consent authorities, consultation, the preparation of assessments of environmental effects (AEEs), the lodging of consent applications, pre-hearings, hearing procedures, rights of appeal, and RCA actions following the gaining of consents.

Chapter 5 summarises the current state of scientific knowledge about the effects of stormwater run-off from roads on different receiving environments. It also identifies potential mitigation measures available to road designers and road managers with cross-references to Chapter 6 Engineering Methods for Stormwater Management.

The purpose of the chapter is to provide information relevant to the preparation of AEEs (Chapter 4) and to the incorporation of mitigation measures into the design of new roads and the retrofitting of existing roads.

Chapter 6 identifies “best practice” engineering methods for managing stormwater run-off from roads with comment on the advantages and disadvantages of each method. The methods relate to the design of new roads and the retrofitting of existing roads.

Chapter 7 presents a comprehensive bibliography of stormwater management-related publications. It is in 6 parts that relate to the chapters.

The Guidelines do not purport to present an exhaustive treatment of the above topics. Rather, they attempt to identify the key management tools and issues and to explore the linkages between them. They also identify documents that may be accessed by the reader if further information is required on a specific topic.

Implementation and Outcomes Sought

The outcomes sought by Transfund in promoting these Guidelines are:

- Clarification of the legal rights and obligations of RCAs in respect of stormwater management activities inside and outside road corridors.
- Better understanding of the respective roles and responsibilities of the various agencies with statutory responsibilities relating to the management of stormwater run-off from roads.
- A more consistent approach to the regulation of stormwater management activities by regional councils and territorial authorities throughout the country.
- Better understanding of the environmental effects of stormwater run-off and the mitigation options that are available.
- A more consistent approach to the application of the “best practicable option” requirement in respect of the design of stormwater treatment systems.
- A reduction in delays to gaining resource consents (i.e. the preparation and processing of applications) and hence project implementation.
- Greater appreciation of the merits of adopting a more holistic “whole catchment” approach to management of stormwater run-off from roads.

Although greater consistency in the regulation and engineering of stormwater run-off from roads are among the outcomes sought, it is acknowledged that different regulatory standards and design approaches may be appropriate to different parts of New Zealand depending on local circumstances, such as traffic density (contaminant load), sensitivity of receiving environments, geology, soil type and rainfall intensity.

Legal Framework surrounding the Management of Stormwater Run-off from Roads in New Zealand

The legal framework surrounding the management of stormwater run-off from roads and highways in New Zealand can be divided into primary legislation, secondary legislation, and common law.

Relevant *Primary legislation* includes:

- Land Transport Management Act 2003
- Transit New Zealand Act 1989
- Land Transport Act 1998

- Local Government Act 2002 and 1974
- Resource Management Act 1991

These Acts establish the functions, duties, powers and obligations of the principal agencies having responsibilities for managing and regulating stormwater run-off from roads and state highways, i.e. territorial local authorities, Transit New Zealand, the Minister of Transport, and regional councils.

Secondary legislation, being legislation which has a less direct bearing on stormwater management but which nevertheless contains important provisions (some of which place actual or potential constraints on the actions of RCAs), includes:

- Soil Conservation and Rivers Control Act 1941
- Land Drainage Act 1908
- Local Drainage Acts
- Building Act 1991
- Trespass Act 1980
- Health Act 1956
- Public Works Act 1981

Common law is also relevant to stormwater management. Common law is the body of law developed by the Courts over the years, as opposed to statute law which derives from Acts of Parliament. It includes the torts of negligence and nuisance, and the principles of natural servitude, and breach of statutory duty.

An overview of the legislation as represented in these Acts is given. In approaching stormwater management issues, RCAs should consider two primary questions:

- What rights does the RCA (Territorial Authorities or Transit) have over the property over which the stormwater will pass or in which a drain will be constructed or maintained?
- What compliance obligations does the RCA have to meet?

The powers and rights of Transit and the Minister of Transport, and of Territorial Authorities, for stormwater drainage from highways and roads are discussed, followed by a summary of the compliance obligations of RCAs. Ways of minimising the risk of legal action being taken are identified.

Regulatory and Non-Regulatory Instruments for Stormwater Management

The management of stormwater run-off from roads is put into its wider context, with guidance provided on various regulatory and non-regulatory instrument that are available to local authorities and RCAs.

Regulatory Methods include:

- National environmental standards
- Resource management objectives and policies
- Choice of rule categories
- The framing of rules
- Framing of conditions on resource consents
- Designations
- Structure plans
- Building consents

Non-regulatory methods include:

- Activity/asset management plans
- Integrated catchment management plans

- Codes of practice for land development
- Subdivision guidelines
- Best practice engineering/technical guidelines
- Adoption of SUD (Sustainable Urban Drainage) techniques
- Flood plain management plans
- Engineering methods

Gaining Resource Consents for Stormwater Management

Chapter 4 provides guidance on the following:

- Identifying stormwater management activities potentially requiring resource consents.
- Finding out the consents that are required.
- Key steps in the gaining of consents and “best practice” advice in relation to each of these steps.
- Consulting with actually or potentially affected parties early in the development of the project.
- Preparing the Assessment of Effects on the Environment (AEE).
- Coping with pre-hearing meetings and hearings, rights of objection and appeal, and RCA action after a consent has been granted.

Environmental Effects and Mitigation Measures for Stormwater Management

The uncontrolled run-off of stormwater from roads can lead to a variety of environmental problems including flooding, erosion, road instability, and adverse ecological effects in receiving waters.

Road development contributes to changes in the hydrological regime which can lead to downstream flooding and erosion problems. An altered hydrological regime can also impact directly on aquatic and riparian environments. Similarly, the removal of overhanging vegetation, modifications to streambanks and bed, and the installation of poorly designed culverts can have significant effects on aquatic ecosystems, including fish life.

The road construction phase will often involve vegetation clearance and earthworks which expose soils to erosion by rainfall and stormwater run-off. The mobilisation and transport of sediment can have potentially serious consequences for freshwater and estuarine receiving environments.

Transport-derived contaminants from oil leaks, brake linings, tyre wear and road wear accumulate on road surfaces and are added to by deposition of air-borne particulate materials from vehicle emissions. When rain falls these materials are washed from the road surface into the stormwater system and then into receiving environments such as streams, estuaries and harbours.

The Guidelines canvass the issues referred to above and present the results of relevant New Zealand research. The management implications of research findings are discussed and suggestions are made as to the potential ways and means of avoiding or mitigating adverse effects of roads.

Engineering Methods for Stormwater Management

The engineering response to stormwater management issues is critical because it affects project costs, and an inappropriate choice of design solutions or “treatment” methods can lead to sub-optimal environmental outcomes.

The appropriate response to a stormwater management issue will depend on the local circumstances: the geology and soil type, rainfall, the amount of stormwater, population (traffic density) projections, existing and likely future contaminant loads, the sensitivity of receiving environments.

Chapter 6 of the Guidelines deals with the design of pipes and channels, reduction of peak flows and run-off volumes, selection of the appropriate treatment methods for improving stormwater quality, and preventing erosion and road instability problems. It also identifies methods that can be used to reduce the impacts of land disturbing activities during the construction phase of a roading project. The topics include:

- Importance of route selection
- Assessment of level of service
- Hydrological assessment
- Road surface design

This chapter is not intended to be a “design manual”. Instead, it should be considered a “road map” to point the designer in the right direction in terms of options for designing stormwater management systems, guidance on maintenance requirements, and life-cycle cost considerations. It gives a relatively brief explanation of each issue or technique, and these are listed below. Relevant references are provided in footnotes in the text, and these should be consulted if further information is required.

Guidance on design of drainage systems includes:

- Storage design
- Pipeline design
- Culvert design
- Open drain design

Guidance on surface & subsoil drainage designs covers:

- Water tables
- Catch drains
- Standard subsoil drains
- Interceptor drains
- Pavement drains

Guidance on stormwater treatment system designs covers:

- *Source control methods*: Filter strips; Grass swales; Infiltration trenches/Treatment walls/Trench filters; Porous pavements
- *Top of pipe methods*: Catch pits/sumps; Litter baskets
- *End of pipe methods*: Litter racks; Sediment traps; Gross pollutant traps; Litter booms; Oil/Grit separators; Extended detention basins; Sand filters; Infiltration basins; Constructed wetlands
- *Proprietary systems*
- *SUD methods*

Other topics covered in Chapter 6 are:

- Retrofitting of stormwater control and treatment systems
- Erosion and sediment control during construction
- Maintenance of treatment devices and conveyance structures
- Life-cycle costing considerations such as costs for planning and construction, establishment, maintenance, and monitoring
- Maintenance and monitoring requirements for different treatment methods (tabulated for easy reference)

Abstract

These Guidelines for integrated stormwater management, prepared in 2003-2004, provide guidance on a range of issues relating to the management of stormwater run-off from state highways and local roads in New Zealand, including:

- The legal framework within which stormwater management takes place
- The management framework (agency responsibilities and management tools)
- The gaining of resource consents for stormwater management activities
- Environmental effects and mitigation measures
- Best practice engineering methods

In addition to road designers, engineers and managers, the Guidelines are for the use of other parties, including roading contractors, resource management agencies (regional councils, territorial local authorities), stormwater asset managers, consultants, iwi, environmental groups, and the general public.

1. Introduction

1.1 Purpose of Guidelines

These Guidelines provide guidance on a range of issues relating to the management of stormwater run-off from state highways and local roads in New Zealand, including:

- The legal framework within which stormwater management takes place
- The management framework (agency responsibilities and management tools)
- The gaining of resource consents for stormwater management activities
- Environmental effects and mitigation measures
- Best practice engineering methods

The Guidelines have been prepared with the primary aim of assisting road controlling authorities (RCAs), for Transit New Zealand (TNZ) and Transfund New Zealand, to come to grips with the sometimes complex issues surrounding the matters referred to above, and the interplay between them.

In addition to road designers, engineers and managers, it is anticipated that the Guidelines will be of interest and use to a number of other parties, including roading contractors, resource management agencies (regional councils, territorial local authorities (TAs)), stormwater asset managers, consultants, iwi, environmental groups, and the general public.

1.2 Meaning of “Stormwater Management”

The term “stormwater management”, as applied to the management of run-off from roads, is used holistically in these Guidelines. It refers to all those activities, or any particular activity, actually or potentially affecting the rate, quantity and quality of run-off from roads irrespective of who is undertaking the activity, and whether or not the activity is being undertaken within a roading corridor.

This wide approach to the definition of stormwater management, and hence to the preparation of the Guidelines, has been taken because the activities of a number of parties – including RCAs, private landowners, land developers and regulatory authorities – can affect the quantity and quality of stormwater entering and being discharged from the road corridor. It is important that all parties understand the potential effects of their activities, their respective rights and responsibilities, and the available opportunities for avoiding or mitigating the adverse effects of stormwater run-off.

Stormwater management activities may include:

- Rules in regional plans regulating activities such as earth disturbances, damming of waterways, diversions, taking of water, disturbance of riverbeds and foreshore, placement of structures in river beds or within the coastal marine area, and the discharge of stormwater to land, freshwater bodies or the coastal marine area.

- Rules in district plans regulating (minor) earth disturbances.
- The activities of private landowners in respect of development of land adjacent to or adjoining highways or local roads (e.g. subdivision, construction of private drains, and connections to public drains).
- Construction and maintenance of public drains and channels outside roading corridors by TAs under the provisions of the Local Government Act and the Land Drainage Act.
- The activities of RCAs (TNZ and TAs) within or outside roading corridors, including the design, construction and maintenance of drains and culverts.
- The selection of engineering methods by RCAs (run-off control and/or contaminant control).

1.3 Definitions & Abbreviations

1.3.1 Definitions

“**Activity**” means a land transport output or capital project, or both.

“**Activity class**” means a group of activities.

“**Amenity values**” means those natural or physical qualities and characteristics of an area that contribute to people’s appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes [section (S) 2 Resource Management Act (RMA) 1994].

“**Annual plan**” means an annual plan adopted under section 95 of the Local Government Act (LGA) 2002.

“**Best practicable option**”, in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to:

- (a) The nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and
- (b) The financial implications, and the effects on the environment, of that option when compared with other options; and
- (c) The current state of technical knowledge and the likelihood that the option can be successfully applied [S2 RMA].

“**Certificate of compliance**” means a certificate granted by a local authority under section 139 of the RMA.

“**Coastal marine area**” means the foreshore, seabed, and coastal water, and the air space above the water –

- (a) Of which the seaward boundary is the outer limits of the territorial sea:

- (b) Of which the landward boundary is the line of mean high water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of –
- (i) One kilometre upstream from the mouth of the river; or
 - (ii) The point upstream that is calculated by multiplying the width of the river mouth by five [S2 RMA].

“Coastal permit” has the meaning set out in section 87(c) of the RMA.

“Conditions”, in relation to plans and resource consents, includes terms, standards, restrictions, and prohibitions [S2 RMA].

“Consent authority” means the Minister of Conservation, a regional council, a territorial authority, or a local authority that is both a regional council and a territorial authority, whose permission is required to carry out an activity for which a resource consent is required under the RMA.

“Controlled activity” means an activity described in section 77B(2) of the RMA.

“Designation” has the meaning set out in section 166 of the RMA.

“Discharge” includes emit, deposit, and allow to escape [S2 RMA].

“Discharge permit” has the meaning set out in section 87(e) of the RMA.

“Discretionary activity” means an activity described in section 77B(4) of the RMA.

“District”, in relation to a territorial authority means the district of the territorial authority as defined in accordance with the Local Government Act 2002 but does not include any area in the coastal marine area.

“Drain” means a passage, channel, or pipe on, over, or under the ground for the reception and discharge of stormwater or pollutants, whether continuously or intermittently [S43 Transit New Zealand Act (TNZA) 1989].

“Environment” includes –

- (a) Ecosystems and their constituent parts, including people and communities; and
- (b) All natural and physical resources; and
- (c) Amenity values; and
- (d) The social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) of this definition of which are affected by those matters [S2 RMA].

“Iwi authority” means the authority which represents an iwi and which is recognised by that iwi as having authority to do so.

“Kaitiakitanga” means the exercise of guardianship by the tangata whenua of an area in accordance with tikanga Maori in relation to natural and physical resources; and includes the ethic of stewardship.

“Land” includes any estate or interest in land.

“Land transport programme” means a land transport programme prepared under section 12 Land Transport Management Act 2003 (LTMA) as from time to time amended or varied.

“Land use consent” has the meaning set out in section 87(a) of the RMA.

“Local authority” means a regional council or territorial authority. Has the same meaning as in section 5(1) of the LGA 2002.

“Local road” means a road (other than a state highway) in the district, and under the control, of a territorial authority.

“Long-term council community plan” means a long-term council community plan adopted under section 93 of the LGA 2002.

“Motorway” means a motorway declared as such by the Governor-General in Council under section 138 of the Public Works Act 1981 or under section 71 of this Act; and includes all bridges, drains, culverts, or other structures or works forming part of any motorway so declared; but does not include any local road, access way, or service lane (or the supports of any such road, way, or lane) that crosses over or under a motorway on a different level [S21 TNZA 1989].

“National land transport fund” means the dedicated part of the Crown Bank Account into which land transport revenue is paid under section 8 of the LTMA.

“National land transport programme” means a national land transport programme adopted under section 19 of the LTMA, as from time to time amended or varied.

“National land transport strategy” has the same meaning as in section 2(1) of the Land Transport Act (LTA) 1998.

“National policy statement” means a statement issued under section 52 of the RMA.

“Network utility operator” has the meaning set out in section 166 of the RMA.

“Permitted activity” means an activity described in section 77B(1) of the RMA.

“Public work” has the same meaning as in the Public Works Act 1981, and includes any existing or proposed public reserve within the meaning of the Reserves Act 1977 and any national park purposes under the National Parks Act 1980 [S2 RMA].

“Region”

- (a) means the region of a regional council; and
- (b) includes the district of a territorial authority, if the territorial authority is a unitary authority [S5 LGA 2002].

“Regional land transport strategy” has the same meaning as in section 2(1) of the Land Transport Act 1998.

“Regional plan” means an operative plan (including a regional coastal plan) approved by a regional council or the Minister of Conservation under Schedule 1; and includes all operative changes to such a plan (whether arising from a review or otherwise).

“Requiring authority” has the meaning set out in section 166 of the RMA.

“Resource consent” has the meaning set out in section 87 of the RMA; and includes all conditions to which the consent is subject.

“Restricted discretionary activity” means an activity described in section 77B(3) of the RMA.

“River” means a continually or intermittently flowing body of fresh water; and includes a stream and modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal) [S2 RMA].

“River bed”, refer definition of **“bed”** in section 2 of the RMA.

“Road” has the same meaning as in section 315 of the LGA; and includes a motorway as defined in section 2(1) of the TNZA. Refer also sections 43(1), 51(1) and 55 of the TNZA 1989 for other definitions in specific contexts.

“Road controlling authority”, in relation to a road, means the Minister, Department of State, Crown entity, State enterprise, or territorial authority that controls the road.

“Rule” means a district rule or a regional rule [S2 RMA].

“State highway” means a State highway declared as such under section 11 of the National Roads Act 1953 or by the Authority under the TNZA 1989; and, for the purposes of any payments from the Account, also includes any proposed State highway [S22(1) TNZA 1989].

“Stormwater management” – refer to Section 1.2 above in these Guidelines.

“Territorial authority” has the same meaning as in section 5(1) of the LGA 2002.

“Transfund” means Transfund New Zealand, as continued by section 66 of the LTMA 2003.

“**Transit**” means Transit New Zealand, as continued by section 75 of the LTMA 2003.

1.3.2 Abbreviations

AEE	Assessment of Environmental Effects
AMP	Activity/asset management plan
ANZECC	Australia and New Zealand Environment and Conservation Council
ARC	Auckland Regional Council
BPO	Best Practicable Option
CMA	Coastal Marine Area
CPLD	Code of Practice for Land Development
DOC	Department of Conservation
ICMP	Integrated Catchment Management Plan
LDA	Land Drainage Act 1908
LGA	Local Government Act 1974, 2002
LTA	Land Transport Act 1998
LTCCP	Long-Term Council Community Plan
LTMA	Land Transport Management Act 2003
MFE	Ministry for the Environment
MOT	Ministry of Transport
PAH	Polycyclic aromatic hydrocarbon
RCA	Road Controlling Authority
RMA	Resource Management Act 1991
SCM	Source Control Method
SC&RCA	Soil Conservation & Rivers Control Act 1941
STM	Source Treatment Method
SUD	Sustainable Urban Drainage
SVOC	Semi-volatile Organic Compound
TA	Territorial Authority
TBL	Triple Bottom Line
TNZ	Transit New Zealand
TNZA	Transit New Zealand Act
TPH	Total Petroleum Hydrocarbons
VOC	Volatile Organic Compound

1.4 Scope and Layout of Guidelines

The Guidelines are divided into the following chapters:

Chapter 1 (Introduction) sets out the purpose of the Guidelines, the definition adopted for “stormwater management” (Section 1.2 of this report), and the outcomes sought. It also discusses various contextual issues

surrounding the drive towards more sustainable methods of stormwater management and the key issue of what constitutes “best practice” in a given situation.

Chapter 2 Summarises the legal framework surrounding the management of stormwater run-off from highways and roads in New Zealand and identifies key agency responsibilities, rights and obligations.

Chapter 3 Outlines the management framework for managing stormwater run-off in New Zealand (including run-off from roads), focusing on the regulatory and non-regulatory methods that are available to the various agencies with stormwater management responsibilities. Some guidance is provided to regional and district councils in relation to the framing of objectives, policies and rules for the management of stormwater run-off from roads. The purpose of the chapter is to establish a context for the stormwater management activities undertaken by RCAs.

Chapter 4 Summarises the process for gaining resource consents for stormwater management activities, including the identification of consent requirements, interaction with consent authorities, consultation, the preparation of assessments of environmental effects (AEEs), the lodging of consent applications, pre-hearings, hearing procedures, rights of appeal, and RCA actions following the gaining of consents.

Chapter 5 Summarises the current state of scientific knowledge about the effects of stormwater run-off from roads on different receiving environments. It also identifies potential mitigation measures available to road designers and road managers with cross-references to Chapter 6 Engineering Methods. The purpose of the section is to provide information relevant to the preparation of AEEs (Chapter 4) and to the incorporation of mitigation measures into the design of new roads and the retrofitting of existing roads.

Chapter 6 Identifies “best practice” engineering methods for managing stormwater run-off from roads with comment on the advantages and disadvantages of each method. The methods relate to both the design of new roads and the retrofitting of existing roads.

Chapter 7 Presents a comprehensive bibliography of stormwater management-related publications.

The Guidelines do not purport to present an exhaustive treatment of the above topics. Rather, they attempt to identify the key management tools and issues and to explore the linkages between them. They also identify documents that may be accessed by the reader if further information is required on a specific topic.

1.5 Implementation and Outcomes Sought

As noted above, the anticipation is that these Guidelines may be used by RCAs (TNZ and TAs), regional councils, territorial local authorities (for regulatory purposes as well as asset management purposes), private landowners, and other stakeholder groups.

Stakeholders	Vehicle for implementation
Road controlling authorities (TNZ and TAs)	Design, construction and maintenance of new roads including drainage systems and treatment, retrofitting of existing roads. Preparation of AEEs, resource consent applications.
Regional councils	Objectives, policies and rules in regional plans. Resource consent conditions.
Territorial local authorities	Rules in district plans. Consent conditions. Provisions of LGA asset management plans.
Private landowners	Design, construction and maintenance of drainage systems. Submissions on roading proposals.
Environmental groups, iwi	Submissions on roading proposals.

The outcomes sought by Transfund in promoting these Guidelines are:

- Clarification of the legal rights and obligations of RCAs in respect of stormwater management activities inside and outside the road corridors.
- Better understanding of the respective roles and responsibilities of the various agencies with statutory responsibilities relating to the management of stormwater run-off from roads.
- A more consistent approach to the regulation of stormwater management activities by regional councils and territorial authorities throughout the country.
- Better understanding of the environmental effects of stormwater run-off and the mitigation options that are available.
- A more consistent approach to the application of the “best practicable option” requirement in respect of the design of stormwater treatment systems.
- A reduction in delays to gaining resource consents (i.e. the preparation and processing of applications), and hence delays to project implementation.
- Greater appreciation of the merits of adopting a more holistic “whole catchment” approach to management of stormwater run-off from roads.

Although greater consistency in the regulation and engineering of stormwater run-off from roads are among the outcomes sought, it is acknowledged that different regulatory standards and design approaches may be appropriate to different parts of New Zealand depending on local circumstances, such as traffic density (contaminant load), sensitivity of receiving environments, geology, soil type and rainfall intensity.

1.6 Existing Guidelines and Standards

Several regional councils and some district councils have produced guidelines and/or standards (e.g. bylaws, design standards) pertaining to the management of stormwater run-off. Most of these documents relate to the management of urban run-off and few of them are focused specifically on management of road run-off.

Auckland Regional Council, Waitakere City Council, Christchurch City Council and Wellington Regional Council, in particular, have produced some useful guidelines, as follows:

Auckland Regional Council

- TP10 Stormwater Treatment Devices: Design Guideline Manual. *ARC Technical Publication No. 10*, 2002
- TP90 Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland Regional. *ARC Technical Publication No. 90*, 1999
- TP108 Guidelines for Stormwater Run-off Modelling in the Auckland Region. *ARC Technical Publication No. 108*, 1999
- TP124 Low Impact Design Manual for the Auckland Region. *ARC Technical Publication No. 124*, 2000

Waitakere City Council

- Guidelines for Best Practice – Water Management, 1999
- Comprehensive Urban Stormwater Management Strategy and Action Plan, 2000
- Countryside and Foothills Stormwater Management Code of Practice, 2001

Christchurch City Council

- Natural Asset Management Strategy for Waterways and Wetlands
- Waterways, Wetlands and Drainage Guide; Part A: Visions, Part B: Design

Wellington Regional Council

- Erosion and Sediment Control Guidelines for the Wellington Region (September 2002)

The guidelines and standards are used, to varying degrees, as the basis for regulatory activity (see Section 3.2 of these Guidelines).

The guidelines and standards do not have any standing outside their region or district of origin. The only exception to this is the New Zealand Standard SNZ HB 44:2001 *Subdivision for People and the Environment* which is referred to in Section 3.3.4 of these Guidelines.

Stormwater management guideline documents used in New Zealand and overseas are listed in Chapter 7, Bibliography.

1.7 Context of Guidelines

These Guidelines have been developed within the context of:

- The Land Transport Management Act 2003 which provides an integrated and long-term approach to land transport management and funding, with more emphasis (than previously) on social and environmental needs. Under the Act, Transfund (when it is considering funding applications) and Transit (when it is preparing its land transport programme) are required to take into account the objectives of the New Zealand Transport Strategy.
- The New Zealand Transport Strategy which defines the government's vision for transport and, among other things, sets an objective of ensuring environmental sustainability, said to involve reduction of negative impacts on land, air, water, communities and ecosystems.
- The Local Government Act 2002 which requires local authorities to take a "sustainable development" approach in promoting the social, economic, environmental and cultural well-being of their communities; see Section 2.2.4 of this document.
- The Resource Management Act 1991 (RMA) whose purpose requires those exercising powers and functions under it to promote the "sustainable management" of natural resources (including soil and water) and physical resources (which include roads and drains); see Section 3.1.3 of this document.
- International "best practice" which increasingly recognises that:
 - A more holistic "whole catchment" approach to the management of stormwater, including run-off from roads, is desirable.
 - Stormwater should not be managed in isolation from other water systems; i.e. where practical, stormwater management should be integrated with the management of water supplies, wastewater and natural waters (e.g. rivers, wetlands).¹
 - Stormwater management should be integrated with land use activities, e.g. subdivision activities, parks and reserves management and road reserves management.
 - Stormwater drains and channels should be designed and managed (and if necessary, reconfigured) to maximise natural habitat values and to enhance landscape and recreational values.
 - Conflict can exist between the objectives of maintaining and enhancing habitat, landscape and recreational values and the objective of promoting hydraulic efficiency in drainage channels. Sometimes the benefits of the former will outweigh the benefits of the latter in terms of enhancement of the quality of the total environment and avoidance of downstream flooding (high peak flows).

¹ The desirability of adopting a more integrated approach of this nature, in New Zealand, has been recognised in the Parliamentary Commissioner for the Environment's report *Beyond Ageing Pipes – Urban Water Systems for the 21st Century* (2001).

- Greater emphasis is needed on source control of contaminants (e.g. low impact design techniques such as swale development) as opposed to reliance on “end of pipe” solutions, i.e. treatment systems.

1.8 National Consistency with Local Flexibility

A survey undertaken by the NZWWA (New Zealand Water & Wastes Association) Drainage Manager’s Group found that RCAs generally wish to see greater national consistency in respect of the regulation of stormwater management activities, including in the design of rules the types of conditions attached to resource consents and the application of the “best practicable option” requirement. A commonly expressed view was that highly variable regulatory requirements make it difficult or impossible to predict what is acceptable.

On the other hand, there is an awareness of the potential pitfalls of an overly prescriptive approach. RCAs generally recognise that a need is to retain sufficient flexibility within the regulatory system to enable rules, consent conditions and engineering methods to be tailored to the local circumstances. For example, it is recognised that the requirements for stormwater controls in intensively developed or developing urban areas are likely to be different from those in sparsely settled rural areas with little growth. Also recognised is that some receiving environments are more sensitive than others either by virtue of their recreational, ecological or intrinsic values or because of the extent of existing contamination.

In short, an appropriate balance is sought between national consistency and local flexibility. As indicated above, one of Transfund’s objectives in preparing these guidelines is to promote a degree of national consistency in regulatory approaches to managing stormwater run-off from roads.

1.9 Meaning of “Best Practicable Option”

One of the areas of greatest concern to RCAs is the highly variable, and sometimes inappropriate, way in which local authorities have applied “best practice” requirements to roading projects. Conditions on permitted activity rules commonly indicate that a stormwater discharge is permitted subject to the implementation of a “best practicable option” (BPO) treatment method. Councils sometimes also attach a BPO condition to a discharge consent.

However, BPO does not necessarily mean the adoption of “best management practice” or the best available option. The term “best practicable option” is defined in section 2 of the RMA: the effect of the definition is that, when deciding whether a particular treatment method conforms with a BPO condition, councils are required to have regard to the costs of any options and the practicalities of implementing them under the circumstances, as well as the nature of the discharge and the sensitivity of the receiving environment. The implication is that costly options are not warranted where the potential for significant adverse effects to occur is low (see Section 3.2.3 of these Guidelines).

2. Legal Framework surrounding the Management of Stormwater Run-off from Roads in New Zealand

2.1 Introduction

The legal framework surrounding the management of stormwater run-off from roads and highways in New Zealand can be divided into primary legislation, secondary legislation, and common law.

Primary legislation is:

- Land Transport Management Act 2003
- Transit New Zealand Act 1989
- Land Transport Act 1998
- Local Government Act 2002 And 1974
- Resource Management Act 1991

These Acts establish the functions, duties, powers and obligations of the principal agencies having responsibilities for managing and regulating stormwater run-off from roads and state highways, i.e. territorial local authorities, Transit New Zealand, the Minister of Transport, and regional councils (Table 2.1).

Secondary legislation, being legislation which has a less direct bearing on stormwater management but which nevertheless contains important provisions (some of which place actual or potential constraints on the actions of RCAs), includes:

- Soil Conservation and Rivers Control Act 1941
- Land Drainage Act 1908
- Local Drainage Acts
- Building Act 1991
- Trespass Act 1980
- Health Act 1956
- Public Works Act 1981

Common law is also relevant to stormwater management. Common law is the body of law developed by the Courts over the years, as opposed to statute law which derives from Acts of Parliament. It includes the torts of negligence and nuisance, and the principles of natural servitude, and breach of statutory duty (Section 2.5.3 of these Guidelines).

In approaching stormwater management issues, RCAs should consider two primary questions:

- (a) What rights does the RCA (TA or Transit) have over the property over which the stormwater will pass or in which a drain will be constructed or maintained?
- (b) What compliance obligations does the RCA have to meet?

2. *Legal Framework surrounding Management of Stormwater Run-off from Roads in NZ*

Table 2.1: Summary of key agency responsibilities for management of stormwater run-off from highways and roads in New Zealand.

Agency	Responsibility	Legislation
Government/ Minister of Transport	Preparation of National Land Transport Strategy (not obligatory). Transport legislation.	S170 (Part 13) LTA
Transfund	Allocation of roading resources (including resources applied to management of stormwater run-off from roads); administration of National Land Transport Fund. Preparation of annual National Land Transport Programme.	S10, S68 LTMA S19 LTMA
Transit	Operation/management of State Highway system including planning, design, supervision, construction and maintenance of stormwater drainage system. Preparation of annual Land Transport Programme for State Highway system.	S77 LTMA S12 LTMA
Regional Councils	Preparation of Regional Land Transport Strategy. Preparation of annual Land Transport Programme. Preparation and administration of regional resource management plans governing: earth disturbance activities, damming and diversion of waterways, taking of water, disturbance of riverbeds and the foreshore, placement of structures in/on riverbeds and foreshore, stormwater discharges to freshwater or coastal water, and maintenance activities.	S175 LTA S12 LTMA S9-15 RMA (See Table 4.1 of these Guidelines)
Territorial Authorities	Operation/management of local roads, including management of stormwater run-off. Preparation of annual Land Transport Programmes. Preparation of long-term Council Community Plans. Preparation and administration of district plans governing (minor) earthworks activities and, in some cases, vegetation removal.	LGA S12 LTMA S93 LGA S9 RMA

Note: LTMA = Land Transport Management Act 2003
LTA = Land Transport Act 1998
RMA = Resource Management Act 1991
LGA = Local Government Act 2002 and 1974

The first question concerns the permissive powers that an RCA has to operate on its own land or on that of others (Sections 2.3 and 2.4 of these Guidelines), and the second question concerns the need to comply with obligations imposed by legislation or common law (Section 2.5).

2.2 Overview of Legislation

2.2.1 Land Transport Management Act 2003

The purpose of the Land Transport Management Act 2003 (LTMA) is:

To contribute to the aim of achieving an integrated, safe, responsive and sustainable land transport system.

While the Transit New Zealand Act 1989 (Section 2.2.3 of these Guidelines) originally created Transfund New Zealand (Transfund) and Transit New Zealand (Transit), the objectives, purposes and functions of these Crown entities were restated and broadened (in line with the above purpose) by the LTMA.

Transfund's statutory objective (S68 LTMA) is to allocate resources in a way that contributes to an integrated, safe, responsive and sustainable land transport system (Transfund administers the National Land Transport Fund established under S10 of the Act) and, in meeting its objective, Transfund is required to exhibit a sense of social and environmental responsibility which includes avoiding, to the extent reasonable in the circumstances, adverse effects on the environment.

Transit's statutory objective (S77 LTMA) is to operate the State Highway system in a way that contributes to an integrated, safe, responsive and sustainable land transport system and, as with Transfund, Transit is required to exhibit a sense of social and environmental responsibility, etc.

The functions of Transit include control of the State Highway system (including planning, design, supervision, construction and maintenance) and the preparation of a land transport programme (next paragraph) for the State Highway system.

The LTMA (S12) imposes a requirement for preparation of land transport programmes, each financial year, by "appropriate organisations" (including Transit, regional councils and territorial authorities). A land transport programme must list activities (e.g. construction of stormwater management facilities) for which payment is sought from Transfund or the Land Transport Safety Authority (LTSA) and must take into account how each activity, among other things², ensures environmental sustainability.

A local authority need not prepare a land transport programme for a financial year if its long-term council community plan (see Section 2.2.4 below) or annual plan includes the matters to be in a land transport programme (S13 LTMA).

The LTMA (S19) requires Transfund to prepare and adopt a National Land Transport Programme each financial year and, in preparing the programme, Transfund is required to take into account any current National Land Transport Strategy and the relevant regional land transport strategies (Section 2.2.2, below).

² The other matters which must be taken into account include how the activity assists economic development, assists safety and personal security, improves access and mobility, and protects and promotes public health.

2. Legal Framework surrounding Management of Stormwater Run-off from Roads in NZ

Section 20 of the LTMA empowers Transfund to approve an activity as qualifying for payments from the National Land Transport Account.

Sections 15–18 of the LTMA set out extensive consultation requirements which must be adhered to by Transit, regional councils and TAs when preparing land transport programmes.

2.2.2 Land Transport Act 1998

The Land Transport Act 1998 (LTA) requires the LTSA, Transfund and Transit to ensure that, in exercising their functions, duties and responsibilities, they take into account any current National Land Transport Strategy.

The LTA (section 175) provides for the preparation of regional land transport strategies by regional councils and the councils are required, among other things, to take into account how the strategy ensures environmental sustainability.

Section 179 of the LTA sets out extensive consultation requirements to be adhered to by regional councils when preparing regional land transport strategies.

2.2.3 Transit New Zealand Act 1989

The Transit New Zealand Act (TNZA) sets out the rights, powers and obligations of Transit and the Minister in respect of the management of stormwater run-off from state highways and government roads. Details are provided in Sections 2.4 and 2.5 of these Guidelines.

2.2.4 Local Government Act 2002, 1974

The Local Government Act 2002

Section 10 of the Local Government Act 2002 (LGA) states that the purpose of local government in New Zealand is:

- (a) *to enable democratic local decision-making and action by, and on behalf of, communities; and*
- (b) *to promote the social, economic, environmental, and cultural well-being of communities, in the present and for the future.*

Section 11 of the LGA states that the role of a local authority is to:

- (a) *give effect, in relation to its district or region, to the purpose of local government stated in section 10; and*
- (b) *perform the duties, and exercise the rights, conferred on it by or under this Act and any other enactment.*

Section 14 of the LGA requires that, in performing its role, a local authority must act in accordance with specified principles, including:

- (h) *in taking a sustainable development approach, a local authority should take into account -*
 - (i) *The social, economic, and cultural well-being of people and communities; and*

- (ii) The need to maintain and enhance the quality of the environment; and*
- (iii) The reasonably foreseeable needs of future generations.*

Subsection 12(2) of the LGA confers wide powers upon local authorities:

For the purpose of performing its role, a local authority has –

- (a) Full capacity to carry on or undertake any activity or business, do any act, or enter into any transaction; and*
- (b) For the purposes of paragraph (a), full rights, powers and privileges.*

Subsection 12(3) provides that:

Subsection 12 (2) is subject to this Act, any other enactment and the general law.

Section 93 of the LGA requires local authorities to have a Long-Term Council Community Plan covering a period of not less than 10 consecutive financial years.

Subsection 93(6) states the purpose of a Long-Term Community Plan is to:

- (a) describe the activities of the local authority; and*
- (b) describe the community outcomes of the local authority's district or region; and*
- (c) provide integrated decision-making and co-ordination of the resource of the local authority; and*
- (d) provide a long-term focus for the decisions and activities of the local authority; and*
- (e) provide a basis for accountability of the local authority to the community; and*
- (f) provide an opportunity for participation by the public in decision-making processes on activities to be undertaken by the local authority.*

Schedule 10, Part 1, of the Act requires that a Long-Term Community Plan must identify, among other things:

- (d) the assets or groups of assets required by the group of activities and identify, in relation to those assets –*
 - (i) how the local authority will assess and manage the asset management implications of changes to*
 - (A) demand for, or consumption of, relevant services; and*
 - (B) service provision levels and standards.*

In other words, activities such as stormwater management are linked to long-term community planning and the asset management requirements of the LGA.

2. Legal Framework surrounding Management of Stormwater Run-off from Roads in NZ

Under section 125 of the LGA, a territorial authority must, from time to time, assess the provision within its district of water services. Water services include stormwater drainage (as well as drinking water and sewage disposal). The assessment of water services must, among other things, contain a description of the means by which stormwater is disposed of within the district including the extent to which drainage works are provided (S126, LGA). The first water services assessment must be completed no later than 30th June 2005.

An assessment of water services must contain a statement of current and estimated future demands for water services within the district, a statement of any issues relating to the health and environmental impacts of discharges of stormwater, and a statement of the TA's proposals for meeting current and future demands, including proposals for any new or replacement infrastructure (S126(1), LGA).

The Local Government Act 1974

The Local Government Act 1974 contained a large number of provisions relating to the management of stormwater run-off from roads. The Local Government Act 2002 repealed many of these provisions³ (including most of Part XXVI Sewerage and Stormwater Drainage by Territorial Authorities) in favour of the introduction of more permissive general powers and the requirement to undertake the water services assessments referred to above.

However, some of the provisions of the 1974 Act relating to stormwater management, including sections of Part XXI (Roads) and Part XXVI (Sewage and Stormwater Drainage) and all of Part XXIX (Land Drainage and River Clearance), were retained. The provisions of the 1974 Act that were *not* repealed by the 2002 Act are identified in Schedule 18 of the 2002 Act. The residual powers, rights and obligations of TAs in respect of stormwater drainage from roads under the 1974 legislation are identified in Sections 2.4 and 2.5 of these Guidelines.

A TA's powers in relation to drainage channels and land drainage works only apply if a "land drainage area" has been constituted under S504 of the 1974 Act.

Where the establishment orders provide, the responsibilities of regional councils under the LGA include the functions, duties and powers of a land drainage board under the Land Drainage Act (see Section 2.2.6 below) and the functions, duties and powers of a TA under Part XXIX of the 1974 Act.

A definition of "drainage channel" is set out in section 503 of the 1974 Act, of which the crucial ingredient is that the channel was constructed by the Council as a drainage channel or is vested in the Council as such.

2.2.5 Resource Management Act 1991

The purpose of the Resource Management Act (RMA) is to promote the sustainable management of natural and physical resources (Part II, S5 of the RMA).

³ The provisions of the 1974 LGA that were repealed related to the *permissive* powers of local authorities [such provisions being replaced by general permissive powers; see section 12(2) LGA 2002 above], not to the council's regulatory or coercive powers.

The RMA provides for the preparation of regional policy statements and regional and district resource management plans which, once approved, effectively become part of the legislative framework governing stormwater management.

Regional councils, under section 30 of the RMA, control the discharge of contaminants into or onto land, air or water, the discharge of water into water, and the discharge of contaminants to the coastal marine area. These functions are pivotal to the management of stormwater. Regional Councils, through rules in regional plans, may declare certain stormwater discharges to be permitted activities (subject to compliance with specified conditions) or may require dischargers, including RCAs, to apply for discharge consents from the Council under section 15 of the RMA (see Section 3.2.4 *The Framing of Rules* in these Guidelines).

Regional councils also exercise regulatory control over other stormwater management-related activities (e.g. the damming and diversion of water, the disturbance of riverbeds and foreshores, and the placement of structures in same). Again, rules in plans may require RCAs to comply with relevant permitted activity conditions or apply for consents to undertake such activities.

In the absence of relevant rules in plans, the default position under sections 12–15 of the RMA is that resource consent is required for activities other than land use activities.

Territorial authorities, under section 31 of the RMA, are responsible for achieving integrated management of the effects of the use, development or protection of land and associated natural and physical resources, and the control of subdivision of land.

Objectives, policies and rules giving effect to the responsibilities of regional councils and territorial authorities are to be found in a variety of documents. Some regional councils prepare a separate Regional Discharges to Land Plan and a Regional Freshwater Plan (dealing among other things with discharges to freshwater bodies) and some combine the two. Some councils have separate plans dealing with activities in river and lake beds. All regional councils have a Regional Coastal Plan which may contain objectives, policies and rules pertaining to the discharge of stormwater to the coastal marine area, and the placement of culverts or other structures within the coastal marine areas. All territorial authorities prepare District Plans.

In addition to functions related directly to the management of stormwater run-off from roads, both regional councils and TAs have functions relating to the wider context of catchment management and the control of land use activities with the potential to affect both the quantity and the quality of stormwater reporting to roadside drains. That is, some aspects of the RMA relate *indirectly* to the management of road run-off. The importance of viewing, and where possible dealing with, the management of stormwater run-off in a wider catchment context (particularly in the urban environment) is referred to in Sections 1.2 and 1.5 of these Guidelines, and Chapter 3 provides some guidance as to how this can be achieved.

2.2.6 Land Drainage Act 1908

The Land Drainage Act 1908 (LDA) makes provision for the constitution of Drainage Districts and Land Drainage Boards and it sets out the powers of Boards.

All land drainage boards were dissolved by the Local Government Re-organisation Orders 1989, and their functions, duties and powers were given to territorial authorities or regional councils. In urban areas, drainage districts were deemed to be “urban drainage areas” constituted pursuant to section 443 of the LGA 1974 (now repealed) or “drainage areas” constituted under section 504 of the LGA 1974. The provisions of the LGA (1974 and 2002) in respect of TA management of urban drainage therefore effectively subsume the provisions of the LDA.

Regional councils were given the functions and power of a drainage board under the LDA for managing drainage districts in *rural* areas. These include the power to construct and maintain drains and watercourses on public and private land (S17, S23 LDA), and the power to construct, reconstruct, alter, repair and maintain all such works as necessary for the purposes of controlling or regulating the flow of water towards, in or from watercourses, preventing or lessening any likelihood of the overflow or breaking of the banks of any watercourse, preventing or lessening erosion and the promotion of soil conservation. The LDA defines a “drain” to include every passage, natural watercourse, or channel on land or underground through which water flows continuously or otherwise, except a navigable river. The LDA defines a “watercourse” as including all rivers, streams and channels through which water flows.

The re-organisation orders also gave regional councils the powers of a territorial authority under Part XXIX (Land Drainage and River Clearance) of the LGA to do works and undertake duties within rural drainage districts, including land drainage, control of drainage channels and drainage works, and removal of obstacles from drainage channels and watercourses.

Regional councils do not have any responsibility for drainage outside any specified drainage district.

The LDA is not specific to the management of stormwater run-off from roads and its provisions relating to the construction and maintenance of drains adjacent to roads are to a large extent, if not wholly, duplicated by the more comprehensive provisions of the LGA.

2.2.7 Soil Conservation and Rivers Control Act 1941

The objectives of the Soil Conservation and Rivers Control Act (SC&RCA), administered by regional councils, are the promotion of soil conservation, the prevention and mitigation of soil erosion, the prevention of damage by floods and the utilisation of lands in such a manner as will tend towards the attainment of those objectives. The Act’s provisions are not dissimilar to those of the LDA.

Section 126(2) of the Act states that each Board (Regional Council) shall have the power to construct, reconstruct, alter, repair, and maintain all works as necessary for

the purposes of controlling or regulating the flow of water towards, into or from watercourses, preventing or lessening any likelihood of the overflow or breaking of the banks of any watercourse.

Section 133 of the Act provides that the regional council may, for the purposes of the Act, clean, repair or otherwise maintain or improve any watercourse or outfall for water; remove any groynes, stopbanks, dams, weirs, trees, plants or debris or any other obstruction to the free flow of water; or raise widen or deepen any defence against the water. It may also make any new watercourse or new outfall for water and connect it, and erect any new defence against water.

Thus, while the SC&RCA is generally concerned with stormwater management, its focus is on encouraging the free flow of water [see *Atlas Properties Limited and others v the Kapiti District Council* (High Court CP No. 172/00, judgement of Durie J, 19 Dec 2001)] and, like the LDA, its provisions are not specific to roads.

2.2.8 Other Legislation

The Building Act 1991 imposes certain obligations in respect of the building of structures or “building works” which may be relevant to stormwater management structures (Section 2.5.2 of these Guidelines).

The Trespass Act 1980 creates the potential for a trespassing offence to occur if proper procedures have not been followed (Section 2.5.2 of these Guidelines).

The provisions of the Health Act 1956 impose, or can be used to impose, certain obligations on RCAs (Section 2.5.2 of these Guidelines).

2.3 Powers and Rights of Transit New Zealand and Minister of Transport in respect to Stormwater Drainage from Highways

The powers and rights of Transit and the Minister of Transport in respect to the management of stormwater run-off from roads are set out in the Transit New Zealand Act 1989.

2.3.1 General Powers

Transit has the power to do all things necessary to construct, and maintain in good repair, any state highway (S61, TNZ Act 1989).

2.3.2 Drainage Works during Construction of Motorway

Transit may undertake such drainage works as are necessary in the construction of a motorway (S73, TNZ Act 1989).

2.3.3 Ability to Enter onto Land to Construct/Maintain Ditches, Drains and Other Conduits

Transit may enter on any land, and make and maintain such ditches, drains and conduits as may be required to drain water from any state highway, and to erect floodgates and to open or close them (S61(4)(j), TNZ Act 1989).

Transit may enter on any land to remove material from any culvert, river, stream, lake or other water, to prevent damage to any part of a state highway (S61(4)(m), TNZ Act 1989).

In respect of any Government road, the Minister of Transport may enter on any land, and make and keep clear existing ditches, drains, and conduits as may be required from any road (S48(3)(j), TNZ Act 1989).

In respect of any Government road, the Minister may enter on any land to remove material from any culvert, river, stream, lake, or other water, to prevent damage to any part of a road under the Minister's control (S48(3)(m), TNZ Act 1989).

2.3.4 Power to Require Movement of Existing Structure

The authority with control of a road (including either Transit or the Minister) may require an existing structure (including a drain) to be moved for safety or improvement purposes (S54, TNZ Act 1989).

2.3.5 Common Law Rights

Under common law, Transit and the Minister have the right to discharge "naturally occurring" water from high land to low land (see Principle of Natural Servitude, Section 2.5.3 of these Guidelines).

2.3.6 Private Property Agreements

As with TAs (Section 2.4.6 of these Guidelines), Transit has the ability to negotiate private property agreements with landowners.

2.3.7 Summary

A summary of key rights and powers of the Minister of Transport and Transit concerning stormwater drainage off highways is tabulated (Table 2.2, p. 36).

2.4 Powers and Rights of Territorial Authorities in respect to Stormwater Drainage from Roads

2.4.1 General Powers

As noted in Section 2.2.4 above, subsection 12(2) of the LGA 2002 confers wide powers on local authorities, effectively allowing them to do anything subject to the specific requirements of that Act, any other enactment and the general law.

Table 2.2: Summary of key rights and powers of the Minister of Transport and Transit in respect of stormwater drainage off highways.

Rights & Powers	Transit NZ Act	Common Law
In respect of any Government road, the Minister may enter on any land and make and keep clear existing ditches, drains, and conduits as may be required to drain water from any road.	S48(3)(j)	
In respect of any Government road the Minister may enter on any land to remove material from any culvert, river, stream, lake, or other water, to prevent damage to any part of a road under the Minister's control.	S48(3)(m)	
The authority with control of a road (including either Transit or the Minister) may require an existing structure (including a drain) to be moved for safety or improvement purposes.	S54	
Transit shall have power to do all things necessary to construct and maintain in good repair any state highway, including: <ul style="list-style-type: none"> - To enter on any land and make and maintain such ditches, drains, and conduits as may be required to drain water from any state highway, and to erect floodgates and to open or close them. - To enter on any land to remove material from any culvert, river, stream, lake, or other water, to prevent damage to any part of a state highway. 	S61 S61(4)(j) S61(4)(m)	
Transit may undertake such drainage works as are necessary in the construction of a motorway.	S73	
Transit has the right to discharge "naturally occurring" water from higher land to lower land.		●

2.4.2 Distinction between "Public" and "Private" Drains

The LGA 1974 makes an important distinction between public and private drains. However, what constitutes a public drain is not precisely defined.

A public drain can exist on a private property and a TA can declare a private drain to be a public drain (S462).

It is important for a TA, when contemplating any work, to consider whether a drain is a public drain or a private drain as the status of the drain can affect the TA's rights and how they may be exercised.

In *Apra v Wellington City Council* [1969] NZLR 409, the High Court set out a number of tests to determine what is a public drain, including:

- i. Was it constructed at public expense by the TA?
- ii. Has control and maintenance of the drain been taken over by the TA?
- iii. Do two or more owners have the right to discharge their drain into it?

2.4.3 Territorial Authority Powers in respect of Public Drains

If a drain is deemed to be a public drain, a TA has the following powers under the LGA:

- **Ability to construct and maintain drains on Council-owned land and on private land**

Section 181 LGA 2002 enables TAs, subject to the provisions of the Public Works Act as to compensation for “injurious affection”, to cause to be constructed on or under private land such works for stormwater drainage as it considers necessary. The prior consent in writing of the owner is needed but, if it is not obtained, the Council can use the procedure set out in Schedule 12 of the Act. If works are constructed on private land, the Council can at any time afterwards enter on that land to alter, renew or repair or clean the works when required, after first giving notice to the owner of the intended entry.

The Council, if using its powers under section 181 of the LGA 2002 to construct works for stormwater discharge on private land with the permission of the landowner, should keep on file copies of all such permissions because they will bind subsequent landowners. The Council, when constructing such works, will also need to take care that the works themselves do not cause an increased water flow onto private lands below those on which the works are carried out.

TAs may remove obstructions from a drainage channel or watercourse where the free flow of water is impeded by any obstruction, and that obstruction is likely to cause loss of life, injury, or damage to property in the district or to obstruct navigation (S511 LGA 1974).

- **Coverage of a watercourse**

TAs may cover in a watercourse within the District to make it a public drain where that watercourse is or is likely to become a nuisance or dangerous to public health. (Note that special notice requirements have to followed.) The TA may also do such work as in its opinion is necessary to exclude from any watercourse any pollutant and may straighten up or otherwise alter the course and direction of any watercourse (S446 LGA 1974).

- **Alterations to layout of public drains**

TAs may enter into an agreement with a person who requires to alter the layout of a public drain for their own purposes (e.g. new building requirements). The alteration must have TA approval and the person requiring the alteration has to pay all direct and indirect costs (S451 LGA 1974).

- **Power to require removal of trees**

TAs can require the owner/occupier of land to cut down or remove any tree where the roots enter or are likely to enter a public drain (S468 LGA 1974).

- **Entry to property for the purposes of inspecting or maintaining drainage works**

Under the LGA 2002, local authorities have a general power of entry onto land or into buildings. If the land or buildings are occupied it must give reasonable notice of its intention to enter –

- (a) To the occupier not less than 24 hours in advance, and
- (b) To the owner if the occupier is not also the owner, as early as reasonably practicable before entry, or as soon as reasonable practicable after entry has been made (S171 LGA 2002).

Local authorities also have powers of entry for enforcement purposes (S172) and, in an emergency, entry may be made without notice (S173). It is an offence to obstruct such entry and punishable by a fine (S229, S242(2)).

If the offence continues it can be restrained by injunction (S162).

2.4.4 Territorial Authority Powers in respect of Private Drains

- **Power to require provision and maintenance of private drains**

TAs may require the owner of any land or building within the district to construct or lay a private drain from any land or building which is not drained to the satisfaction of council and to connect that private drain to a public drain, or a watercourse or the sea. TAs can also require the owner of the property to clean, maintain, or alter the course of, any private drain (S459 LGA 1974).

- **Power to construct private drains**

Under certain circumstances, TAs have the ability to enter properties, undertake the construction of private drains and recover the costs of doing so from the owner to be served by the private drain (S460 LGA 1974).

- **Alterations to private drains**

TAs may require the owner of any pipe or drain on or under a road to raise, lower or otherwise alter the same, as the Council directs and, if that alteration is not made within a reasonable time, Council may do the work itself. The costs of such work and any damages arising fall to the TA (S337 LGA 1974).

TAs may take up, disconnect, alter, relay or otherwise deal with any private drains, communicating with any watercourse (S446 LGA 1974).

- **Ability to pursue prosecutions against persons making unlawful connections of private drains to public drains**

It is an offence for any person not having the written authority of the TA to connect a private drain with a public drain. TAs may replace or repair any property destroyed or damaged by any such unlawful connections of a private drain, or remove or alter any such private drain, and may recover from that person the full cost of the work and the full amount of any damage done or caused by that person (S467 LGA 1974).

2.4.5 Common Law Rights

Under common law, TAs have the right to discharge “naturally occurring” water from high land to lower land (see Principle of Natural Servitude, Section 2.5.3 of these Guidelines).

If a TA has roads from which water has been discharged for some years onto private land without complaint, the Council may be able to rely on natural servitude for continuing discharge, provided it is not carrying out works that will increase or alter the flow.

If a TA is sealing or otherwise altering such roads, it may be able to rely on the principle of natural servitude, providing it does not cause damage to lower lying lands by altering, as a result of those works, either the way in which the water flows on those lands or the concentration or velocity in or with which it flows on to them.

The TA, if forming new roads, probably cannot rely at all on the principle of natural servitude and may have to either get easements for the conveyance of stormwater or rely on its statutory powers. This is because the new road normally will increase and concentrate the natural flow of the water onto the lower lying land.

2.4.6 Private Property Agreements

While statutes provide a TA with statutory rights, it is important to remember that rights can be held by private agreement or grant.

Therefore a landowner may consent to give up certain rights by agreement (usually resulting in payment of money to the landowner): the most obvious examples are a lease or an easement.

A local authority can obtain an easement by *contract* agreement with a private landowner which will permit the drainage of water through that owner's land. The line of the easement will need to be surveyed and the easement registered against the landowner's title.

Under section 220(1)(f) of the Resource Management Act 1991, a TA can require a developer to provide an easement for stormwater disposed over land within a subdivision, and onto land outside a subdivision. It is quite common for local authorities to require drainage easements when approving subdivisions. However, as with any condition imposed on subdivision approval, such a requirement must be reasonable and justified.

When a council is deciding whether it should take an easement for stormwater drainage over private lands or rely upon its statutory rights, the *costs* of each option will need consideration. The easement procedure will involve both survey and legal costs. However, if a landowner is willing to grant an easement for small or no consideration, the survey and legal costs may be less than the cost of compensating the landowner for injurious affection under section 181 of the LGA 2002 (see Section 2.4.3 of these Guidelines).

2.4.7 Use of Public Works Act

A local authority can, if necessary, use the powers given by the Public Works Act to acquire for a public work, either by agreement or compulsorily, private land over which it wishes to drain water.

2.4.8 Summary

The key powers and rights of TAs in respect of stormwater drainage from roads are summarised in Table 2.3 below.

Table 2.3: Summary of key rights and powers of Territorial Authorities in respect of stormwater drainage off roads.

Rights and powers	Local Government Act	Common Law
Wide general powers	S12(2) LGA 2002	
Declaration of a private drain to be a public drain	S462 LGA 1974	
Ability to construct and maintain drains on Council-owned land and on private land	S181 LGA 2002 S511 LGA 1974	
Ability to cover a watercourse	S446 LGA 1974	
Alteration to layout of public drains	S451 LGA 1974	
Power to require removal of trees	S468 LGA 1974	
Ability to enter property to inspect or maintain drainage works	S171 LGA 2002	
Powers of entry for enforcement and in an emergency	S171, 172, 173, 229, 242, 162 LGA 2002	
Power to require provision and maintenance of private drains	S459 LGA 1974	
Power to construct private drains	S460 LGA 1974	
Alterations to private drains	S337, 446 LGA 1974	
Pursuit of prosecutions against persons unlawfully connecting private drains to public drains	S467 LGA 1974	
Repair of private drains	S467 LGA 1974	
TAs have the right to discharge “naturally occurring” water from higher land to lower land (see Principle of Natural Servitude, Section 2.5.3)		●

2.5 Compliance Obligations of Road Controlling Authorities in respect of Stormwater Drainage from Highways and Roads

2.5.1 Introduction

As above, the powers and rights of RCAs (the Minister, Transit, Territorial Authorities) may be subject to obligations to comply with legislation or the common law.

Some compliance obligations also exist independently of the exercise of a power or right. In other words, they must be complied with, independently of anything that an RCA intends doing.

2.5.2 Obligations Arising from Statute Law

- **Resource Management Act 1991**

Under the RMA, a prohibition exists against the taking, use, damming or diversion of water, or the discharge of contaminants or other water into water, unless allowed by a rule in a Regional Plan or by a resource consent (S14 and S15, RMA). It is an offence for any person to contravene these requirements.

Punishment of an offence under the RMA can be by way of a substantial fine and/or a term of imprisonment.

Therefore, before undertaking any work on a stormwater system, any person should consider whether the relevant Regional Plan allows such work as a “permitted activity”, whether the activity is “prohibited”, or whether a resource consent is required.

As noted in Section 2.2.5 of these Guidelines, much of the detail regarding regulation of the discharge of stormwater will be found in relevant planning documents. Although the provisions relating to discharge of stormwater in the RMA (paragraph 1 above) are minimal, the provisions are highly relevant and failure to ensure compliance with those provisions can lead to a prosecution.

Section 17 of the RMA places a general duty on “every person” to avoid, remedy, or mitigate any adverse effects on the environment arising from an activity carried on by or on behalf of that person, whether or not the activity is in accordance with a rule in a plan, a resource consent or a designation.

- **Building Act 1991**

There is an obligation to undertake any “building work” in accordance with the Building Code (section 7). There is an extensive definition of “building” under the Act (section 3), and “building work” (as defined in section 2) can only be undertaken on a building. Whether or not a building consent is required for a stormwater management-related structure will depend on the facts in any given case.

In the context of utility systems, the decision of *Logan v Auckland City Council*, (2000) 4 NZ ConvC 193,184 Court of Appeal, is relevant. Here the Court indicated that a bund was not “building work” within the meaning of the Act, as it was part of a network utility system for the purpose of reticulating another property. It therefore fell under an exclusion to building work under section 3(1)(a) of the Building Act.

Operators should also be aware that, in practice, not all TAs take the same view as to when a building consent is required. If in doubt, appropriate enquiry should be made.

- **Local Government Act 1974**
Schedule 14 of the LGA 1974 provides for detailed notification requirements prior to carrying out work in an area not under the control of the TA undertaking the work.
- **Transit New Zealand Act 1989**
The consent of any controlling authority (whether Transit, the Minister of Transport or a TA) is required before undertaking work on any road (section 52). There are notice requirements that must be observed when undertaking works outside the road reserve (S48, 54, 61 and 77).
- **Trespass Act 1980**
It is an offence under the Trespass Act 1980 to trespass on any place and, after being warned to leave, to refuse to do so (S4 and S5).

The act of trespassing requires an unlawful entry onto the property of another. As long as a person is lawfully on another's property (e.g. under a power given under statute for which the correct procedures have been followed), no trespass can occur. For example, it is not deemed to be a trespass where access is gained under section 171 of the LGA 2002.

As an example however of the consequences of not following the correct procedures in dealing with landowners, see *Roberts v Rodney District Council* (no. 2) (Barker J, High Court Auckland, judgment 4th May 2001). In this case substantial damages were awarded against a TA which had not adequately complied with its obligations under section 708 and the 16th Schedule of the Local Government Act 1974. [Note: section 708 and the 16th Schedule of the LGA 1974 were repealed by the LGA 2002, their provisions being replaced by section 181 of the LGA 2002 (see Section 2.4.3 of these Guidelines)].

RCAs should ensure, at all times, that they have the appropriate authority to enter onto another's land to carry out a given task.

- **Health Act 1956**
The purpose of the Health Act is to protect and promote public health. In pursuit of this the Minister of Health may require a TA to provide or improve sanitary works. This includes drainage works. It is more likely that the Health Act (S30) will apply more to sewerage works than stormwater works but these are not excluded.

It is an offence under the Health Act to allow a drain to become a nuisance.

2.5.3 Obligations Arising from Common Law

“Common Law”, being the law as developed by the Courts over the years, defines the rights and obligations of a party. While those rights and obligations can be, and frequently are, altered by Acts of Parliament, it is important to recognise that the common law provides a baseline starting point. It is then necessary to consider whether or not and to what extent statute law has modified common law rights.

2. Legal Framework surrounding Management of Stormwater Run-off from Roads in NZ

The common law provides a number of rights or obligations that are owed to others, providing a remedy to an affected party if those obligations are breached. The most relevant of these are:

- ***Negligence*** (linked to “duty of care”)

The most likely form of common law action is a claim in negligence.

An action in negligence arises when someone owes another person a “duty of care”, and that duty is breached by some unreasonable act or omission causing foreseeable loss to the other person.

To whom a duty of care is owed will in most cases be reasonably clear. A general test is to say that it is to someone whom a “reasonable person” would have in his or her contemplation when undertaking an act (or omitting to act).

The public road network in New Zealand is managed either by Transit or TAs. These managers can be liable for the negligent acts of their workforce if, for example, a worker negligently installs or blocks a stormwater drain causing flooding.

If there is a failure to do something, categorised as “an omission”, then road managers may also be liable if, for example, loss is caused by inadequate maintenance, e.g. excessive potholing. Historically an argument was made that a highway operator should not be liable for failing to keep the road in good repair where it has been damaged as a consequence of natural causes. However, the law has moved on and this is now unlikely to be the case.

Example

A useful illustration of a case where a TA was sued in negligence and nuisance is *Atlas Properties Ltd v The Kapiti Coast District Council* (High Court CP No. 172/00, judgement 19 December 2001, Durie J).

Facts

A one in one hundred-year storm caused flood damage to a number of properties. The plaintiffs’ claimed that the culvert through which stormwater passed was of an inadequate design in not allowing sufficient stormwater to pass through it, therefore leading to flooding.

The defence of the Council was that it did everything reasonable in the circumstances of the culvert construction and in the knowledge possessed at the time of construction.

There was no dispute that the culvert could not cope with the stormwater flow which led to the flooding in question. There was also evidence that the problem was known to the Council, and evidence of the Council’s stance in relation to the issue and stormwater management generally.

The Judge considered that the most relevant cause of action was negligence in that the “real question was whether the Council was careless in constructing the culvert, or was wrong in not enlarging the culvert when it appeared that the culvert might not be adequate for projected water flows”.

The court found that there was a duty of care owed by the Council to the property owners but, on the facts, there had been no negligence. This was based on the fact that, although

the Council had an expert's report on the capability of the culvert, its approach to the management of the situation was reasonable: *"Standing back from the matter and seeking a broad overview I have come to the conclusion that the Council's actions in planning for a bridge to replace the culvert in the not too distant future, was reasonable having regard to the presumed competing demands on the Council and its assessment of those demands against the risk inherent in the existing floodwater scheme. The Council had to balance a number of competing interests and there is no evidence that in seeking a balance the Council was acting irresponsibly. The evidence is rather that the Council was concerned to take a responsible approach. I find therefore that the Council was not in breach of its duty and that the action must fail."*

- ***Nuisance***

A distinction is made between a "private nuisance" and a "public nuisance". In simple terms, a private nuisance affects an individual's use or enjoyment of property or property rights, whereas a public nuisance will affect the general public's use or enjoyment to a right.

Examples would include the flooding of an adjacent property by altering the drainage system of the locality.

Some common law nuisances are now enshrined in statute (for example, under the Health Act 1956).

A person is liable for a nuisance which they cause and fail to stop. The usual remedy is to obtain an injunction and/or damages. It is the ability to obtain an injunction to prevent a continuing nuisance which can be the main attraction for a third party seeking to enforce its rights.

- ***Natural Servitude***

In defence to a claim brought by a landowner who believes his or her land is being flooded by a higher property, the owner of that higher property may raise the defence of "natural servitude".

Under the principle of natural servitude, lower lying land is obliged to receive stormwater which flows from higher land. This extends to permitting the owner of higher land to concentrate the discharge on the lower land providing that it is in the natural use of that land. What amounts to "natural use" will depend on any particular factual situation.

The principle of natural servitude does have limitations:

- It does not permit the owner of higher land to discharge to the lower land, water which has been actively collected from another catchment area (so called "foreign water");
- It does not permit the owner of the higher land to bring water onto the lower land by "artificial obstruction" (e.g. building, earthworks changing land contours), which then causes damage to the lower land, which damage did not occur when the land received the natural flow.

2. Legal Framework surrounding Management of Stormwater Run-off from Roads in NZ

- "Natural use" will not occur where the flow of water from a road pavement to lower land is altered in concentration or velocity, causing damage which did not occur when the lower land received the water by natural flow. [See *Gazley v Lower Hutt CC* (unreported, HC Wellington, CP 460/90, Neazor J, 20th November 1991)].

Example

In *Davis v Lethbridge* [1976] (NZLR 689 Mahon J) the Court summarised the law relating to the natural servitude in some detail under a case in which the plaintiffs sought damages for nuisance.

Facts

The plaintiffs and defendants were owners of adjoining residential properties in a new subdivision. Prior to the subdivision, the plaintiffs' land would receive surface water from the defendants' land. The prior owner of the defendants' land had built a concrete wall which deflected the natural flow of water from the defendants' land on to the plaintiffs' land. This was the position when the plaintiffs bought their land and then built a house on it. The defendants then bought their land and proceeded to fill the rear part of their land so that it was brought level with the top of the concrete wall. As a result, in heavy rain the surface water from the defendants' land ran over the top of and in some places percolated through the wall, discharging at a point about halfway along the common boundary instead of at the end of it. The plaintiffs sought damages and an injunction to prevent such occurrence.

The High Court set out the rule of natural servitude in detail.

The Court found that the building of the wall was only an intermediate stage, so that when the filling was complete the water flowed as before and therefore the plaintiffs had no right to seek an injunction preventing that flow of water. The Court also reaffirmed the position that there has to be some sort of "substantial harm" for a party to be successful and not merely a claim which technically amounts to a nuisance.

Breach of Statutory Duty

In some cases a statute may create a right for a person to sue a party who does not perform an obligation under a statute; in other words they allege a "breach of statutory duty".

While a possibility of an action based on breach of statutory duty cannot be discounted in this area, it is probable that a more favourable cause of action would exist to a defendant in negligence or possibly nuisance.

For example, in *Longhurst v Wellington City Council* (CP 565/92, High Court Wellington, 23 November 1993, Doogue J), it was held that there was no claim available to a plaintiff that a defendant Council had failed to mark a public drain on a drainage map, as required by section 444(1) of the Local Government Act as the Judge considered that the section was not intended to create a private right of action. The law in this area turns on the wording of the specific section of an Act. In the context of the LGA or TNZA a claim in negligence or nuisance is far more likely.

2.5.4 Summary of Compliance Obligations

Table 2.4: Summary of obligations of road controlling authorities in respect of stormwater drainage off highways and roads.

Compliance Obligation	RMA	Building Act	Local Govt Act	Transit NZ Act	Trespass Act	Health Act	Common Law
Ensure that all works are authorised by a rule in a plan or by a resource consent	S9, 12, 13, 14, 15						
Avoid, remedy, mitigate any adverse effects on environment	S17						
Ensure all “building work” complies with Building Code		S7, 3					
Notification of proposed works			Schedule 14 LGA 1974				
Consent of relevant RCA required before undertaking works within road reserve				S52			
Notice requirements in respect of works on land not forming part of road reserve				S48, 54, 61, 77			
Transit to minimise interference with existing drainage pattern				S77			
Any person must ensure that they are legally entitled to be on another’s property					S4, 5		
Owners of drains under obligation not to allow drain to become a nuisance						S30	●
Not to commit an act or omission resulting in breach of “duty of care” (negligence)							●

2.6 Minimising the Risk of Legal Action

Cases that have reached Court concerning stormwater fall into two general categories:

1. A challenge by another party to the work being undertaken at all.
2. Dealing with the consequences of work having been lawfully undertaken.

The statutory rules that exist provide a code for the undertaking of work. If those rules are followed closely, and a clear paper trail is kept to demonstrate compliance (for example of notices given to private owners), then a challenge by another party to the legality of work being carried out should not be successful.

In *Roberts v Rodney District Council (No 2)*, failure to comply with the procedures set out in the LGA resulted in a significant award of damages as the work subsequently carried out then amounted to a trespass.

It is possible that, in the case of non-compliance with the necessary rules, an owner could obtain an injunction to prevent or even remove unlawful work.

The golden rule therefore is to carefully follow any statutory procedures set out in the legislation. *If any particular situation on the ground causes doubt, take legal advice if necessary.*

Assuming that the work can be undertaken legally, it is sensible to consider (before the work is undertaken) if any other party will become affected by that work to the extent that it will give them a right to seek a remedy against some wrong.

Therefore consider:

- (a) Has the appropriate procedure been followed as set down by the legislation in order for the work to lawfully proceed?
- (b) If so, will the work result in an increased volume or velocity of water onto another property causing flooding for which a landowner might sue in due course?
- (c) Will any other harm result for which a landowner might sue in due course?

In some cases it is possible that work is necessary which will inevitably lead to a result whereby flooding will be caused to private property where none previously occurred. Such a situation should be considered in advance and appropriate strategies should be employed to minimise the risk of litigation, including the canvassing of all possible alternatives and the use of private agreements (which can include payment for compensation, agreement to pay for the cost of upgrading private drains, etc.). It may also be necessary to work with the appropriate local authorities.

3. Regulatory and Non-Regulatory Stormwater Management Instruments

3.1 Introduction

3.1.1 Overview

This chapter of the Guidelines endeavours to place the management of stormwater run-off from roads in its wider context. It also provides guidance on the various regulatory and non-regulatory instruments that are available to local authorities (in their capacity as resource managers) and to RCAs (as asset managers) for the purposes of stormwater management, and the linkages between them.

The instruments or methods are summarised in Figure 3.1 and discussed in following sections.

3.1.2 Role of Strategic Plans

New Zealand Land Transport Strategy

The purpose of the current New Zealand Land Transport Strategy, released on 03 December 2002, is to guide decision making in central government and its various agencies, and to provide a point of reference for local government, businesses and the community.

The stated Government vision is that:

By 2010, New Zealand will have an affordable, integrated, safe, responsive and sustainable transport system.

One of the aims of the strategy is to ensure that the past emphasis on economic efficiency will be replaced with a requirement that all project evaluations for land infrastructure incorporate social, economic and environmental costs and benefits in the decision-making process.

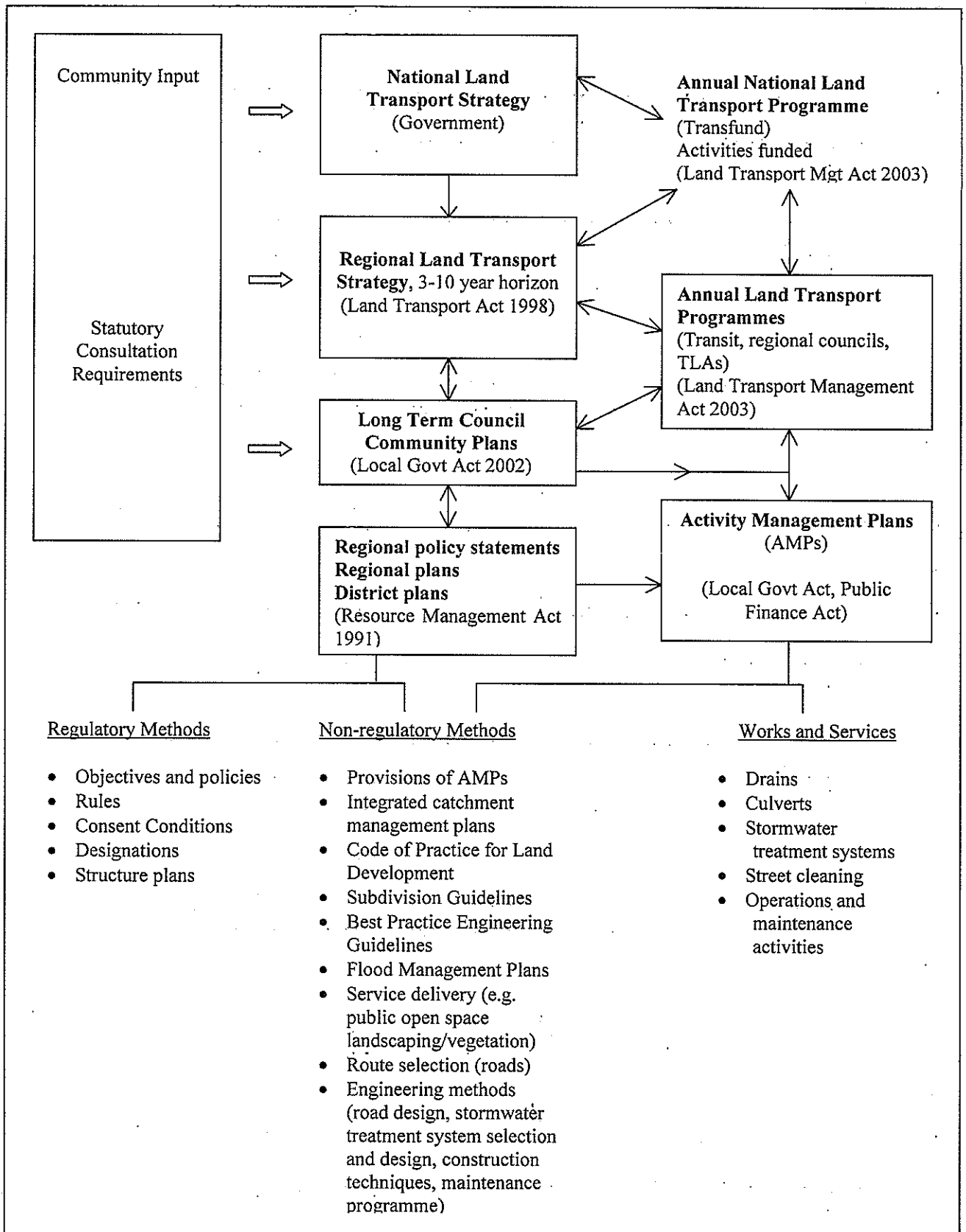
State Highway strategies

Transit has a Strategic Plan and a National State Highway Strategy.

Transit's Vision Statement and some of its key Goals are directly or indirectly related to the issue of managing stormwater from state highways:

<p style="text-align: center;">Transit New Zealand Vision</p> <p style="text-align: center;">“A world leader in roading solutions”</p>

Figure 3.1 Stormwater management instruments and methods.



Transit goals include:

- Plan and develop an integrated, safe, responsive and sustainable highway system
- Maintain, operate and protect the state highway system
- Exercise social and environmental responsibility in all our activities

Transit has stated its intention of preparing an Environmental Strategy which will establish an environmental framework, including goals and objectives, commensurate with the principles of sustainable development. Transit has also adopted the “triple bottom line” (TBL) approach to reporting on its performance.

The preparation of an environmental strategy and the adoption of TBL reporting provide opportunity for Transit to further develop and elaborate on its strategies and performance criteria for managing stormwater run-off from existing and new state highways.

Regional transport strategies

Under sections 175 and 176 of the Land Transport Act 1989, every regional council has to prepare a Regional Land Transport Strategy which will identify integrated, safe, responsive and sustainable means of responding to the future land transport needs of the region, taking into account, among other things, the need to minimise adverse effects on the environment.

Local community strategies

In the past, most councils produced a strategic plan of some sort, with such plans providing an opportunity for them to set out social, economic and environmental goals for their districts or regions, having regard to their statutory responsibilities and the aspirations of their communities.

The Local Government Act 2002 provides (S93) for the preparation of Long-Term Council Community Plans (LTCCPs), which are essentially strategic plans. They are among other things to identify the community outcomes sought, describe the activities of the local authority, and provide for integrated decision making and co-ordination of the resources of the local authority. The LTCCP will become the vehicle for integrating social, economic and environmental objectives in the pursuit of sustainable development. Such objectives could relate to the pursuit of more sustainable stormwater management systems, integrated with the management of other water systems.

3.1.3 The Resource Management Act “Driver”

Although the Local Government Act and the Transit New Zealand Act establish the functions, duties and powers of RCAs in respect of the management of stormwater run-off from land and roads (Chapter 2 of these Guidelines), both pieces of legislation are exercised *subject* to the requirements of the RMA and its associated resource management plans. It is the RMA regime (i.e. the Act and the plans) which

establishes the framework of objectives and policies within which the effects of stormwater management activities are managed.

The “sustainable management” purpose of the RMA requires those exercising functions, duties and powers under the RMA to manage *natural and physical resources* in a way which avoids remedies or mitigates any adverse effects of activities on the *environment* (Section 2.2.5 of these Guidelines). Further, section 17 of the RMA places a general duty on “every person” to avoid, remedy, or mitigate any adverse effects of activities on the environment, whether or not the activity is in accordance with a rule in a plan or a resource consent.

The state highway system, and by implication the TA road network, is a “natural and physical resource” in terms of the RMA, and is required to be sustainably managed (*Transit New Zealand v Invercargill City Council*, Environment Court Decision No. 102/92). The “environment” is widely defined in the RMA to include: all natural and physical resources; ecosystems; people and communities, amenity values and the social economic, aesthetic and cultural conditions which affect these matters.

Under section 32 of the RMA, local authorities have an obligation, before adopting a rule, to consider alternative methods of achieving the objective or implementing a policy (including the provision of information, services or incentives), and to undertake a cost-benefit analysis of the available options. In other words, the RMA recognises that regulation is not necessarily the best way of achieving an objective or implementing a policy, and that non-regulatory methods, including provision of works and sources, may play an important role in achieving outcomes.

3.1.4 Role of Land Transport Programmes in Stormwater Management

The preparation of the activities-orientated annual Land Transport Programmes by Transit, regional councils and TAs, and the annual National Land Transport Programme by Transfund (Figure 3.1, Section 2.2.1 of these Guidelines), provides an opportunity to translate national and regional transport strategies into action. The strategies should also have regard to relevant stormwater-related objectives and policies in regional plans. The agencies charged with preparing land transport programming are required to take into account how each activity (for example, management of road run-off) ensures environmental sustainability.

There are similarities between a land transport programme prepared under the Land Transport Management Act 2003 (refer Section 2.2.1 above) and an Activity Management Plan prepared under the Local Government Act 2002 (Section 3.1.5 below), although the former has to be prepared annually. This similarity is reflected in section 13 of the LTMA which provides that a local authority need not prepare a land transport programme for a given financial year if the relevant matters have already been dealt with in the authority’s Long-Term Community Plan or annual plan.

3.1.5 Role of Activity/Asset Management Plans in Stormwater Management

An Activity Management Plan (AMP) is a plan which applies a variety of management, financial, engineering and other practices and techniques to activities and physical assets with the aim of ensuring that the level of service required by present and future customers is provided at the lowest long-term cost to the community.

Activity/Asset Management Objectives

To create, operate, maintain, rehabilitate and replace assets at the required level of service for present and future customers in a cost-effective and environmentally sustainable manner.

AMPs are prepared by TAs and Transit as a means of meeting the financial planning and reporting requirements of the Local Government Act and the Public Finance Act respectively (Section 3.3.1 of this report). However, asset managers, when preparing AMPs, and deciding the appropriate level of service, and expenditure priorities for works and maintenance activities, are able to take into account a wide range of social, economic and environmental considerations.

TAs produce a Roding AMP which, among other things, sets out strategies and work programmes for the provision, upgrading and maintenance of stormwater management-related assets, including kerbs and channels, verges, drains, culverts and stormwater treatment systems, e.g. sumps and catchpits. Transit has also recently produced a draft National Asset Management Plan for management of state highways.

AMPs are components of Long-Term Community Plans (see Figure 3.1) and are themselves important strategic planning documents.

RCAs should ensure that the content of their AMPs is consistent with corporate goals (e.g. pursuit of sustainable development) and the requirements of the RMA and associated resource management documents. For example, they should ensure that:

- Roads and stormwater management facilities are sustainably managed.
- Adverse effects on the environment are avoided, remedied or mitigated.
- Stormwater management activities are consistent with key objectives and policies of regional policy statements, regional plans and district plans.
- Appropriate resources are allocated to achievement of compliance with resource consents.

In summary, while the preparation of AMPs is driven by financial management requirements, they are able to take into account a wide range of considerations. They are also an important means of ensuring that the design, construction and maintenance of roads are aligned with resource management objectives, in particular those that relate to minimisation of the adverse effects of road run-off.

The preparation and use of AMPs as a non-regulatory method of pursuing stormwater management objectives is discussed further in Section 3.3.1 of these Guidelines.

3.2 Regulatory Methods

Regulatory methods are those which place legally binding requirements or constraints on parties undertaking specified activities.

3.2.1 National Environmental Standards

Section 43 of the RMA provides regulation-making powers for prescribing national environmental standards relating to restrictions on the use of land, coastal marine areas, and beds of lakes and rivers, and relating to water or discharges. Standards may cover methods, processes or technology to implement standards.

At the time of production of these Guidelines, there were no national environmental standards pertaining to stormwater management.

3.2.2 Resource Management Objectives and Policies

The objectives and policies contained in approved national and regional policy statements, regional plans and district plans (Section 2.2.3 of these Guidelines) can be viewed as regulatory instruments, because they have to be taken into account when deciding whether or not to grant consent applications and/or the conditions that should be attached to consents (see S104 RMA, and Section 4.14 of these Guidelines).

The appropriate framing of resource management objectives and policies, by regional councils and the regulatory arms of TAs, is therefore very important, and arguably the key to improved management of stormwater. All parties, including RCAs (as asset managers), contractors and the general public, need to know precisely what effects are being managed and what outcomes resource management agencies are endeavouring to achieve.

The objectives and policies of regional policy statements, regional plans and district plans should address, as a matter of priority, the two key stormwater management issues. These are:

- The generation of high volumes and rates of run-off from impervious surfaces (including roads), leading to flooding, erosion and adverse ecological effects), and
- The contaminant content of stormwater run-off, particularly in urban areas (with their high density of roads and traffic) and during the construction phase of development, as such contaminants can cause adverse ecological effects in receiving environments.

(Note: These issues, and the effects that they can have, are summarised in Chapter 5 of these Guidelines.)

The objectives and policies in regional policy standards and regional plans, in addition to reflecting a regional council's RMA responsibilities for the management of water quality and quantity and for integrated land management, may reflect the

council's responsibilities for flood and erosion control under the Soil Conservation and Rivers Control Act 1941 (Section 2.2.7 of these Guidelines).

Objectives should be outcome-orientated and, ideally, progress towards achieving them should be measurable. Policies state a council's attitude or stance in relation to a particular objective, e.g. the matters it will consider or give weight to when deciding a consent application. Policies may also be outcome-orientated, effectively a refinement of an objective. (Note: methods state how policies will be implemented.)

Most current regional plans do not make a distinction between the management of stormwater generally, and the management of stormwater run-off from roads. This approach is acceptable providing methods in the plan provide an indication of how councils propose to promote the sustainable management of run-off from roads. Given the significance of roads as impervious surfaces and potential sources of contaminants, particularly in urban areas, the preferable approach is for regional councils to have specific objectives or policies aimed at the management of road run-off. RCAs would then be left in no doubt as to the approach that they should adopt to issues such as road construction, treatment of run-off, and maintenance of drainage systems.

District plans generally contain few, if any, objectives or policies relating to the management of stormwater run-off from roads, although they can contain objectives and policies relating to integrated catchment management (Section 3.3.2 of these Guidelines) and/or to management of stormwater run-off from areas subject to urban development (see Structure Plans, Section 3.2.7).

3.2.3 Choice of Rule Categories

Rules in resource management plans are generally viewed as the *primary* regulatory method because, once notified, rules have the legal force of regulations, unless the council resolves otherwise.

The choice of rule category (i.e. permitted, controlled, restricted discretionary, discretionary) by regional and district councils – when deciding how best to regulate activities relating to the management of stormwater run-off generally, or roads in particular – is critical because it determines which activities are permitted without the need for the RCA to apply for a consent, which require a consent but cannot be declined, and which require a consent and may be declined.

Each council is responsible for deciding whether it will treat a given activity as a permitted, controlled or discretionary activity, depending on its assessment of the potential for adverse effects to arise from the undertaking of that activity. In the case of stormwater discharges this assessment will include consideration of actual or potential contaminant load and the sensitivity of the receiving environment. Generally, if there is little or no potential for adverse effects to arise, the activity will be *permitted* subject to meeting any conditions attached to the permitted activity rule. Permitted activities can be undertaken as of right and do not require monitoring.

If the potential for effects is a little greater and/or the council wishes to retain control over some aspects of design or environmental performance, the activity will be identified as a *controlled* activity. Controlled activities require consents but consent applications cannot be declined. If the potential for adverse effects to occur as the result of the activity is significant, and the council wishes to subject such activity to full public scrutiny (via rights of objection hearing and appeal) and/or it wishes to retain full discretion over the setting of consent conditions (including monitoring requirements), or retain the ability to decline a consent, then such activities will be identified as *discretionary* activities.

Regional councils throughout New Zealand have, to date, adopted a highly variable approach to the regulation of roading-related stormwater management activities. Some of the activities referred to in Table 4.1 of these Guidelines are treated as permitted activities with easily met conditions. Other councils impose conditions on permitted activity rules for the same activities that are difficult to meet (effectively meaning that a consent is required), and others make the same activities controlled or discretionary.

Another difficulty faced by RCAs, in the past, has been the tendency of councils to adopt a “one rule fits all” approach to the regulation of certain activities (e.g. disturbance of beds of watercourses, placement of structures on the beds of watercourses, stormwater discharges) within a region. For example, some councils treat *all* disturbances to the beds of watercourses and all placements of structures on the beds of watercourses as discretionary activities. The rule category should reflect the potential for adverse effects and hence reflect considerations such as likely sediment or contaminant load and sensitivity of the receiving environment.

The net effect of the above is that RCAs have, in the past, commonly found themselves in the situation of having to apply for consents which would not be needed in another part of the country, or for activities which are demonstrably of low impact. Experience has shown that certain activities relating to the management of stormwater run-off from roads (e.g. culvert extensions and replacements, installation of erosion protection works and most maintenance activities) are inherently low impact, that any effects are temporary and able to be adequately controlled by adherence to some well established management practices. *Such activities should generally be treated as permitted activities, subject to appropriate conditions, thereby avoiding the (unnecessary) costs associated with gaining resource consents.*

The discharge of stormwater run-off from roads into waterbodies (i.e. rivers, lakes, marine waters) can, in most cases, be treated as a permitted activity. However, in some situations, for example where certain stormwater discharges are known to carry substantial contaminant loads or where receiving environments are “sensitive” due to high ecological values or the extent of existing contamination, councils may wish to treat such discharges as controlled or restricted discretionary activities, or possibly even to treat them as a discretionary activity if they wish to retain the ability to decline the consent.

Activities involving minor earthworks, minor disturbances to or depositions onto the beds of waterbodies, minor takes of water, minor diversions and discharges, replacement of existing structures, and the maintenance of drainage channels, can generally be treated as permitted activities.

The placement of new stormwater structures (e.g. culverts), or the extension of existing ones, on the beds of rivers, lakes or in the CMA (i.e. on the foreshore) is appropriately dealt with either as a permitted activity (for small structures) or a controlled or discretionary activity (for larger structures).

3.2.4 The Framing of Rules

The precise wording of rules in regional and district plans is important because this determines what conditions need to be met for permitted activities, what standards apply to controlled activities, and to what matters the Council has restricted the exercise of its discretion, if at all.

Permitted activity rules

Conditions attached to permitted activity rules should be reasonable, clearly expressed, and enforceable. Monitoring conditions cannot be attached to permitted activity rules.

Conditions on permitted activity rules commonly indicate that a stormwater discharge is permitted subject to the implementation of “best practicable option” treatment methods. This is considered to be a reasonable approach providing that councils, and their staff, adhere to the definition of best practicable option in section 2 of the RMA, namely:

The best method for preventing or minimising the adverse effects on the environment having regard, among other things, to –

- (a) The nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and*
- (b) The financial implications, and the effects on the environment, of that option when compared with other options; and*
- (c) The current state of technical knowledge and the likelihood that the option can be successfully applied.*

In other words, when deciding whether a particular method is acceptable and hence whether the discharge meets the permitted activity conditions, councils are required to have regard to the cost of any options and the practicalities of implementing them under the circumstances, as well as the nature of the discharge and the sensitivity of the receiving environment. The implication is that costly options are not warranted where there is low potential for significant adverse effects.

BPO does not necessarily mean the adoption of “best management practice” or the best available option. Rather, the method has to be practicable and appropriate to the circumstances. (Note: the same comment applies to the situation where a council applies a BPO condition to a resource consent.)

Permitted activity rule conditions should not include a requirement to implement “best management practice” (or use similar non-BPO terminology) because this effectively means that the best available technology *has* to be used, irrespective of the cost and the potential for adverse effects.

Controlled activity rules

Controlled activity rules specify activities requiring resource consent, standards and/or terms which the activities are required to meet, and matters which the council has reserved control over for the purposes of assessing a consent application.

Any standards or terms need to be clearly stated and enforceable.

Restricted discretionary activity rules

Restricted discretionary activity rules also specify activities requiring consent and matters over which the council has decided to exercise its discretion when considering an application. (Unlike a controlled activity however, a restricted discretionary activity can be declined.)

Discretionary activity rules

Discretionary activity rules specify activities requiring consent. The consent authority may grant the consent with or without conditions or decline the consent application, and the activity must comply with the standards, terms or conditions, if any, specified in the plan or proposed plan.

Non-complying activity rules

Non-complying activity rules specify activities requiring consent and for which consent may only be granted with or without conditions if the adverse effects of the activity on the environment will be minor, or if the activity would not be contrary to any of the objectives and policies of any plan or proposed plan (see section 104D, RMA).

3.2.5 Framing of Conditions on Resource Consents

A number of activities relating to the management of stormwater run-off from roads potentially require resource consents from regional councils (Table 4.1 in these Guidelines). There are also a number of activities within the catchment of some roads that may affect the quantity of stormwater that has to be handled by RCAs, and which are likely to require consents from TAs (e.g. subdivision, minor land disturbances) or regional councils (e.g. large land disturbances).

Conditions on resource consents are binding on consent holders and may therefore be viewed as regulatory instruments.

Consent conditions are aimed at avoiding, remedying or mitigating adverse effects on the environment.

Conditions must be reasonable, relevant, able to be complied with, and enforceable.

Most projects relating to the construction of new roads will take place within a designated road corridor, so TA consents will not be required for land use providing

that any designation conditions are met (Section 3.2.6 of these Guidelines). However, regional council consents for land disturbance, stormwater discharges and possibly other activities, will be required. Consent conditions may relate to:

- The *design* of the road and its drainage system.
- The *construction phase* of development (e.g. construction methods, control of sediment run-off, use of machinery in waterways, the timing of works (an example could be timing relative to fish spawning), the location of the discharge and its contaminant content).
- The *ongoing management* of stormwater run-off (e.g. treatment systems, maintenance requirements).
- *Monitoring*.

In the case of subdivision consents, conditions may relate to a wide variety of stormwater management issues, including:

- Extent and timing of earth works
- Cut and fill methods
- Drainage and sediment control measures (e.g. sediment ponds, silt fences)
- Retention of natural drainage system
- Planting of riparian buffer strips
- Stabilisation of stockpiles
- Restoration of vegetative cover
- Extent of impervious surfaces
- Provision of constructed devices to control the rate, quantity and quality of run-off (e.g. swales, check dams, detention basins, rain gardens)

In the case of Comprehensive Catchment Discharge Consents (CCDC) of the type issued by the Auckland Regional Council (ARC) to TAs in the Auckland Region⁴, the consent authorises the diversion and discharge of stormwater for an entire catchment. The consent is then issued subject to management of stormwater in the catchment being carried out in accordance with the objectives and policies contained in the Comprehensive Catchment Management Plan. This is required to be submitted with the consent application (Section 3.3.2 in these Guidelines).

Other consent conditions may relate to:

- The staging of development within the catchment.
- Catchment works, including the construction and maintenance of stormwater drains and channels.
- Management of run-off from roads.
- The provision of stormwater treatment facilities and the timing of their installation (usually at the time of subdivision).
- The design of treatment facilities (e.g. in accordance with ARC TP No. 4 “Selection of Stormwater Treatment Volumes for Auckland” and ARC TP No. 10 “Design Guideline Manual, Stormwater Treatment Devices”).

⁴ ARC. 2001. *Guidelines for Comprehensive Catchment Discharge Consents*, January 2001.

- Protection of dwellings (“habitable floor levels”) from flood flows of specified magnitude.

3.2.6 Designations

Designation of land is a method of protecting the future use of the land for a public work, especially construction of new roads. Significant new roads are designated to ensure that the land use activities do not prevent the construction of a road at a future date.

Transit and TAs are requiring authorities under section 166 of the RMA and are able to seek designation of state highways and local roads in district plans in order to protect their interests in a proposed roading corridor. The designation means that no other party can do anything in relation to the land that would prevent or hinder the public work to which the designation relates, without the prior written consent of the requiring authority.

When considering a requirement or any submission received, a TA must consider the effects on the environment of allowing the requirement (i.e. the work to take place), having particular regard to whether adequate consideration has been given to alternative sites, routes, or methods of undertaking the work (S168A(3), RMA).

A requiring authority may, in accordance with the recommendation of the TA (S172 RMA), attach such conditions to the requirement as it considers appropriate, including any conditions relating to the operation or design of the proposed work (S171(2), RMA). Designations for roading projects commonly contain conditions requiring RCAs to handle stormwater management issues in a specified manner.

3.2.7 Structure Plans

The preparation of a structure plan is a regulatory method⁵ to manage the development of “greenfield” areas and areas with residential or business zoning which are as yet undeveloped. Such plans can establish a broad spatial development pattern of land use and a roading and services network which will ensure that the adverse effects of development are addressed in advance of development occurring. (Note: structure plans may also be used as a non-regulatory method to *guide* the development of established urban settlements and address situations where roading, open space or other infrastructure may be deficient.)

Structure plans are essentially integrated utilities plans, which are commonly used in the Auckland Region as a vehicle for implementing Comprehensive Catchment Management Plans (Section 3.2.5 above). As such, they are able to address issues such as roading densities, road alignment and roading drainage.

When used as a regulatory method, structure plans are included in the District Plan to give them statutory effect. An extensive consultation process is associated with the preparation of Structure Plans, including consultation with landowners, the public, and service delivery agencies including RCAs.

⁵ Preparation of structure plans is also used as a non-regulatory method outside the Auckland Region.

TAs should seek input from RCAs when preparing a CCMP or structure plan, and a district plan can require a “notice of requirement” for a designation from a requiring authority to address comprehensive catchment management issues.

3.2.8 Building Consent

TAs consider stormwater management issues for individual properties when they are processing applications for building consents under the Building Act (Section 2.5.2 of these Guidelines). Councils may require provision for on-site disposal of stormwater from roofs or other impervious areas, or they may allow drainage to roadside kerbs. The option of requiring and/or encouraging run-off control measures should be considered.

3.3 Non-regulatory Methods

Non-regulatory methods are methods of achieving objectives and policies other than by way of rules (or other requirements in statutory plans) or consent conditions.

In relation to the management of stormwater run-off from roads, a variety of non-regulatory instruments are available to regional councils and to TAs (in their capacities as resource management agencies or, in the case of TAs, their capacity as owners of roads and stormwater management assets). They include the preparation of: asset management plans, integrated catchment management plans, codes of practice for land development, subdivision guidelines or codes of practice, “best practice” engineering guidelines, adoption of sustainable urban drainage (SUD) techniques, and stormwater or flood management plans. Public education programmes can also play a significant role.

3.3.1 Activity/Asset Management Plans

The Local Government Amendment Act (No. 3) 1996 places an emphasis on long-term financial planning, requiring local authorities to:

- Prepare and adopt every three years a long-term (10 years plus) financial strategy which takes into account asset creation, realisation, and loss of asset service potential.
- In determining their long-term financial strategy, consider all relevant information and assess the cost-benefit of options.
- Adopt a financial system consistent with generally accepted accounting practices.

TAs prepare AMPs as a means of complying with these requirements.

As noted in Section 3.1.5 above, the preparation of AMPs by TAs and Transit, in addition to meeting financial planning requirements, is a means of integrating strategic planning goals and resource management objectives with the operational side of roading infrastructure management, including the provision and maintenance of stormwater collection, treatment and disposal facilities. The RMA and associated policies and plans are key drivers of the content of AMPs.

AMPs should also inform and guide the preparation of Annual Plans and Annual Land Transport Programmes (Figure 3.1).

3. *Regulatory & Non-Regulatory Stormwater Management Instruments*

The activity of asset management is a continual cyclic process that incorporates the concept of continual improvement. Over time it is intended that the asset management plans and processes will be improved with better information, better management systems, and a more holistic life-cycle approach to the long-term management of the infrastructure assets.

All TAs produce a Roothing AMP which deals with the various assets within the road resource including the roads themselves, footpaths, street lighting, traffic management facilities, carparks and service lanes, and drainage facilities. Drainage facilities include:

- Kerbs and grass verges
- Roadside drains and channels
- Culverts
- Sumps, catchpits and serviceholes

Most councils classifying their roads into different service categories along the following lines:

Urban roads	Rural roads
<ul style="list-style-type: none">• Arterial roads• Distributor roads• Collector roads• Access roads• Access places• Carparks and Service lanes	<ul style="list-style-type: none">• Arterial roads• Distributor roads• Collector roads• Access roads• Access places• Carparks and Service lanes

For each roading category, a “level of service” is identified having regard to: statutory requirements (including the RMA, Transit NZ Act, LGA), strategic objectives, and customer expectations. A number of “service indicators” are defined (e.g. frequency and degree of road flooding), and performance measures are established for each service indicator.

The AMP should contain, among other things, plans for road drainage facilities, including strategies and work programmes for maintenance, renewals and asset creation. The TA usually enters into maintenance contracts for most of the maintenance and renewal activities on the road, including maintenance and renewal of drainage facilities. The contracts and the council’s roading accounts and budgets are structured to complement the Transfund funding structures.

Some TAs prepare separate Stormwater AMPs which specifically exclude stormwater drainage assets within the roading corridors. There appears to be little merit in this approach, and the operational side of stormwater management, including run-off from roads, would seem to be better handled by TAs under a single AMP.

Transit NZ has prepared a National Asset Management Plan for state highways and has developed a Maintenance Programme for state highways, including contract standards, related directly to the management of stormwater run-off. The Plan provides a vehicle for Transit NZ to put in place pro-active policies for the

maintenance and replacement of culverts, drains and other components of stormwater infrastructure.

3.3.2 Integrated Catchment Management Plans

Integrated catchment management planning is based on the premise that the catchment is the appropriate scale or unit upon which to base attempts to manage natural and physical resources. The approach is considered to be particularly appropriate to the management of water resources because of the relationships between land use, run-off quantity and quality, habitat maintenance, water supply needs, etc. Integrated catchment management plans (ICMPs) are able to take an holistic and integrated approach to stormwater management, and they also take into account the cumulative effects of different types of land use.

ICMPs are non-statutory documents; they are prepared outside the confines or requirements of the RMA, but they can be identified in resource management plans as non-regulatory methods of achieving resource management objectives.

The ICMP approach is equally applicable to rural and urban areas. It lends itself to community involvement and, in some rural areas of New Zealand, ICMP initiatives are underway involving co-operative efforts between farming communities, resource managers and research scientists.

The Comprehensive Catchment Management Plans (CCMPs) referred to in Section 3.2.5 above, are a form of ICMP applicable to the control of development in urban areas. (Note: to date the term "Comprehensive Catchment Management Plan" has been applied only to urban areas but there is no reason why it could not be extended to rural areas.) ICMPs are non-statutory documents prepared with community input but their contents can be given regulatory force by way of CCMP Stormwater Discharge Consents or by way of inclusion of Structure Plans in District Plans (Sections 3.3.4 and 3.2.7 above).

In the Auckland Region, all TAs are required to prepare CCMPs for areas subject to urban development pressures. The approach attempts to integrate land use, infrastructure management, and stormwater management, while taking into account social, economic and ecological consideration, and amenity values. It is applied to both existing urban areas and to areas that may be urbanised in the future. The approach is set out in Chapter 8 of the Auckland Regional Policy Statement: Water Quality (Sections 8.4.4, 8.4.5, 8.4.7 and 8.4.8); Chapter 11: Natural Hazards (Section 11.4.2) and Appendix A: Catchment Management Planning.

3.3.3 Code of Practice for Land Development

TAs may prepare a Code of Practice for Land Development (CPLD) which, among other things, addresses stormwater management issues with particular reference to the construction phase of development.

CPLDs are generally stand-alone documents which sit outside the district plan. Nevertheless they are complementary to the district plans and are effectively used to help implement it by providing more detailed engineering guidelines, performance

criteria and “acceptable solutions”. TAs use them to assess the construction of subdivisions and land use development, including roads.

In considering an application for subdivision or land use consents, a council may have regard to the outcomes and standards referred to in the CPLD and the extent to which they will be achieved by the development.

3.3.4 Subdivision Guidelines

Most TAs produce subdivision guidelines which sit outside the district plan (i.e. have no statutory basis) but which are commonly cross-referenced to in plans. The net effect of this is that councils can place a considerable amount of weight on them when deciding subdivision applications and consent conditions.

Subdivision guidelines usually cover an entire district. However, in Auckland increasingly they are being prepared as a sub-set of individual structure plans, as a vehicle for implementing the urban design objectives supported by a community.

Subdivision guidelines can contain directives as to the design of subdivisions and the types of “treatment” systems that are acceptable from a stormwater management perspective. For example, they can encourage developers and landowners to design and construct subdivision and dwellings in ways that minimise impervious surfaces, maximise open space around existing water bodies (to provide a buffer), and which make use of so-called “soft” engineering techniques to reduce the volume of run-off and its contaminant load.

It is increasingly common practice for subdivision guidelines to cross-reference to, or require adherence to, the design specifications contained in the types of engineering guideline documents referred to in Section 3.3.5 below.

The Standards New Zealand handbook *Subdivision for People and the Environment* (SNZ HB 44:2001) contains design guidelines for subdivisions aimed at:

- Integrating development with natural water systems through design.
- Encouraging the efficient use of water resources within a development by using stormwater as a potential water source.
- Minimising the amount of stormwater discharged from a site.
- Enhancing the quality of urban stormwater before discharge.

Many of the techniques advocated in SNZ HB 44:2001 are consistent with the so-called SUD approach outlined in Section 3.3.6 below.

There is also a New Zealand Standard *NZS 4404:2004 Land Development and Subdivision Engineering*. (NZ 4404:2004 supersedes NZ 4404:1981.) For those authorities without their own code of practice for land development and subdivision engineering, this Standard offers a convenient way of providing good practice guidelines and a means of compliance for the various types of infrastructure.

“Stormwater Drainage” is dealt with in Part 4 of the Standard. The emphasis is on design and construction standards of piped drainage networks. However, in the General section, the following aspects of stormwater management are included:

- “Permitting” of discharges
- Catchment management planning
- Effects of land use on receiving water
- Alternative stormwater systems
- Catchments and off-site effects

In the New Zealand Building Code, Clause E1 verification method E1/VM1 and Acceptable Solution E1/AS1 are identified as acceptable means of compliance for the design of stormwater drainage works.

The Standard recommends that, for run-off determination relating to areas greater than 100 ha, unsteady flow modelling should be adopted.

“Roads” are covered in Part 3 of the Standard.

Road drainage calculation and design is cross-referenced directly to Part 4 of the Standard. The Standard includes a range of kerb and channel configuration and sump designs.

TAs should ensure that their Subdivision Guidelines and Standards are consistent with both SNZ HB 44:2001 and NZS 4404.

3.3.5 Best Practice Engineering/Technical Guidelines

Some regional councils have produced “best practice” engineering or technical guidelines to assist with stormwater management. Notably the Auckland Regional Council has produced:

- TP10 *Stormwater Treatment Devices: Design Guideline Manual, 2002*
- TP90 *Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region, 1999*
- TP108 *Guidelines for Stormwater Run-off Modelling in the Auckland Region, 1999*
- TP124 *Low Impact Design Manual for the Auckland Region, 2000*

Although these guidelines are not in themselves statutory documents, they have in some cases assumed the status of regulatory or quasi-regulatory instruments by the way they are used by councils. For example TP90 is described as “detailing the rules of the *Proposed Regional Plan: Sediment Control*”, and the recommended design criteria or performance standards contained in the documents are commonly referred to in resource consents issues by the ARC (specified activities “shall be in accordance with...”).

The ARC’s *Stormwater Treatment Devices: Design Guideline Manual* (TP10) provides guidance on the design, construction and maintenance of stormwater treatment devices. These devices aim to:

3. Regulatory & Non-Regulatory Stormwater Management Instruments

- manage flooding and erosion by limiting the volume and peak flow of stormwater run-off, and/or
- remove contaminants from stormwater.

TP10 has been extensively used by consent authorities, developers and consultant engineers. The recently revised TP10 contains some significant changes, including:

- A preference for wetlands over ponds.
- Promoting detention to protect streams from erosion.
- More safety features around ponds.
- Enhancements to allow the use of swales as a stand-alone practice.
- More guidance on practice selection.

And also includes new information on

- Rain-garden design.
- Integrating landscaping issues with device design.
- Outlet protection for erosion control.
- Construction and maintenance monitoring check-lists.
- Household rainwater detention tank design.
- A method for assessing the effectiveness of proprietary treatment systems.
- Green roof design.

Some regional councils have adopted all or part of some of the ARC guidelines for use in other regions. For example, the Wellington Regional Council's *Sediment Guide* is based largely on TP90. Care needs to be exercised in applying the ARC documents to other regions, as some design guidelines or criteria may not be applicable because of differences in climate, geology or soil type.

Some TAs, particularly those in the Auckland Region, also use the ARC documents as quasi-regulatory documents, stating in subdivision consents that activities will be undertaken "in accordance" with the relevant guideline.

Some TAs have produced their own stormwater management related guidelines. For example Christchurch City has provided a *Manual for Design of Waterways, Wetlands and Drainage*, and Waitakere City has produced a *Guideline for Best Practice – Water Management* (see Bibliography).

3.3.6 Adoption of SUD Techniques

Sustainable urban drainage (SUD) techniques have been developed relatively recently as a response to some of the problems associated with conventional urban drainage systems. In particular in response to problems associated with high rates of run-off, concentrated flows (erosion), high contaminant load, and loss of natural "treatment" or assimilative capacity.

SUD is the philosophy of incorporating natural surface water systems (streams, creeks, wetlands) into drainage design and maximising the use of on-site treatment devices with the objective of tackling water quantity and quality problems at source.

SUD adopts an holistic approach. In addition to achieving run-off and water quality control objectives, it aims to enhance recreational, landscape, amenity and ecological values. Opportunities are taken to restore or create habitat and biodiversity. The approach is in line with that promoted by the Parliamentary Commissioner for the Environment⁶, who suggests that systems such as SUD are a key feature of a more integrated catchment-wide approach to stormwater management.

The key to SUD systems is the use of a range of techniques in combination; the challenge to the designer is the selection of the most appropriate system, from a “toolbox” of techniques available, to suit site constraints⁷. Examples of SUD techniques include swales, vegetative filler strips, infiltration trenches, rain gardens, retention ponds and wetlands. SUD solutions generally contain an element of storage of stormwater flows, and an area of retention and treatment to reduce pollutant concentrations.

In the UK, SUD systems are increasingly becoming the preferred approach to the drainage of new developments and are being promoted by the Environment Agency (EA) and the Scottish Environmental Protection Agency (SEPA). Application of SUD and other integrated management approaches in the UK has drawn from experience in other countries such as the USA, Sweden and Australia.

In New Zealand, design guidance for SUD facilities is limited, although some organisations have started to develop strategies for more sustainable stormwater management⁸. There is a need for national guidance to be developed to ensure a consistent approach is adopted.

Berry (2002)⁷ summarises the experience from the practical application of SUD in the UK. His paper contains a table presenting a subjective appraisal of a number of SUD techniques highlighting some of the limitations and benefits of each. It is recognised that site constraints and other site-specific factors will affect the degree to which these limitations or benefits are realised. While prepared on the basis of overseas experience, all the techniques set out in the table are considered to have application in New Zealand, and a number have already been used.

A number of countries including the UK, USA and Australia have developed design guidance for stormwater management and SUD approaches, much of which can be found on the internet. Examples include the UK *SUDS Manual*⁹, the Texas *Non Point Source Book Urban Run-off Quality Best Management Practices*¹⁰, the NSW *Managing Urban Stormwater: Treatment Techniques*¹¹, and *New York State:*

⁶ Parliamentary Commissioner for the Environment (PCE). 2000. *Murky Waters and Ageing Pipes*. PCE. 2001. *Beyond Ageing Pipes*.

⁷ Berry, C. 2002. *Sustainable Urban Drainage – Practical Application and Experience from the UK*. Paper to NZWWA Conference, Christchurch, September 2002.

⁸ Auckland Regional Council. 2000. *Low Impact Design Manual for Auckland Region*. ARC, Auckland.

⁹ CIRIA. 2000. *SUDS Design Manual for Scotland and Northern Ireland*. *CIRIA Report 521*.

¹⁰ US EPA & Texas Natural Resource Conservation Commission. 2002. *Non Point Source Book Urban Run-off Quality Best Management Practices* (www.txnpsbook.org). Maryland USA.

¹¹ NSW EPA. November 1997. *Managing Urban Stormwater: Treatment Techniques*, retrieved from Web site <http://www.epa.nsw.gov.au/stormwater/usp/treattech.pdf>, March 2002.

*Stormwater Management Design Manual*¹². Guidance on design to maximise the ecological value of SUD is contained in SEPA (2000)¹³ and CIRIA Report 539 (2001)¹⁴.

These documents provide guidance on the sizing and design of SUDs features such as ponds, detention basins and swales as well as a methodology for the selection of appropriate features. Although there is some commonality in the documents, care should be exercised in applying the guidance to other countries. Specific guidance for New Zealand is needed to suit the various climatic differences and local requirements. It is important that a holistic approach to design is adopted to balance the quality, quantity and amenity objectives of SUD. This can involve collaboration of a number of disciplines such as planners, ecologists, landscape architects, and engineers (Berry 2002)⁷.

In the UK, cost savings have been achieved through the use of SUD techniques as opposed to conventional piped drainage systems. Attenuation of peak flows substantially reduces the size of downstream pipework, and source control can remove the necessity for much of the conventional drainage infrastructure. It is, however, recognised that the cost of providing features such as wetlands and ponds can be substantially higher than other treatment systems and relative cost-benefit analyses need to be undertaken.

Maintenance costs in the UK for SUD are generally less than for traditional systems, given that there are fewer screens to un-block and fewer gullies to de-silt (SEPA 2000).¹³ It is recommended that a whole-of-life cost assessment be made as a component of feasibility studies. It is hoped that further research and monitoring of systems will provide a better understanding of the cost of the systems.

The main barrier to the uptake of SUD techniques in the UK has been the concern about the responsibility for, and cost of, maintaining what are seen as untried solutions, and a potential burden to existing budgets. Despite the relative newness of SUD, there is growing acceptance that the cost of maintenance of some well-designed systems is no greater than a conventional drainage system or open-landscaped area.¹⁵

3.3.7 Flood Plain Management Plans

Flood plain management plans are prepared by the regional councils. These plans are prepared pursuant to their RMA responsibilities. The flood plain management plans as such do not have statutory backing in terms of enforcement. However, they provide a guide to flooding and stormwater issues on the flood plains for which they are prepared.

¹² Centre for Watershed Protection. October 2001. *New York State: Stormwater Management Design Manual*. <http://centerforwatershedprotection.geomerchant7.com/>

¹³ SEPA. June 2000. *Ponds, Pools and Lochans, Guidance on good practice in the management and creation of small waterbodies in Scotland*.

¹⁴ CIRIA. 2001. Rainwater and Greywater use in buildings, Best Practice Guide. *CIRIA Report 539*.

¹⁵ CIRIA. 2000. Sustainable Urban Drainage Systems, Best Practice Manual. *CIRIA Report 523*.

3.3.8 Engineering Methods

Engineering or service delivery methods are a form of non-regulatory method of achieving objective and implementing policies for stormwater management. They are described in detail in Chapter 6 of these Guidelines.

4. Gaining Resource Consents for Stormwater Management

4.1 Introduction

This section:

- Identifies stormwater management activities potentially requiring resource consents;
- Describes how to find out what consents are required; and
- Summarises the key steps in the gaining of consents and, where appropriate, provides “best practice” advice in relation to each of these steps.

Readers dealing with stormwater management issues relating to state highways are reminded that Transit has both a *Planning Policy Manual* and *Planning Practice Guidelines*, documents that were published in 1999.

4.2 Activities Potentially Requiring Consents

As indicated in Section 3.2.2 of these Guidelines, the RMA provides for regional councils to identify permitted activities, controlled activities and discretionary activities in their plans. The latter two sets of activities require resource consents to be gained, the significant difference being that, in the case of controlled activities, the consents cannot be declined provided that any performance standards specified in the plan are met.

Table 4.1 provides a list of the stormwater management-related activities, which *may* require a resource consent. Whether or not a given activity will actually require a consent depends on the nature of the rules in a regional plan.

4.3 How to Find Out What Consents are Required

The first step towards finding out what stormwater-related consents are required for a particular road construction, road improvement, or road maintenance project is to identify which, if any, of the activities referred to in sections 9, 12, 13 and 15 of the RMA, including those in column one of Table 4.1, will be undertaken during the implementation of the project or work programme:

The next step is to obtain copies of the relevant regional plans. Some councils have combined land, water and air plans which may contain all the information that you need, whereas others have separate plans for land disturbance, land discharges, freshwater, and air.

The final step is to inspect the Rules Section of each plan, locate the rules that relate to the activities identified in the first step (above) and determine the status of each activity, i.e. whether permitted, controlled or discretionary. (Assistance may need to be sought from an experienced RMA practitioner.)

Table 4.1: Stormwater management activities undertaken by RCAs which may require a resource consent.

Stormwater Management Activity	Activity in RMA Terms	Relevant Section of RMA	Consent Type
<p>Earth disturbance activities:</p> <ul style="list-style-type: none"> • Building/construction of new road • Placement of soil/clean fill • Construction of sediment dams, silt traps 	<p>Any use, erection, placement, alteration, extension, removal, demolition of any structure on, under or over the land. Any drilling, excavation, or other disturbance of the land. Any disturbance of the land, habitat of plants, or animals in, on, under the land.</p>	9	Land Use Consent
<p>Damming, diversions, takings:</p> <ul style="list-style-type: none"> • Temporary dams, diversions of streams • Temporary taking of water 	<p>Dam, divert or use water</p>	14	Water Permit
<p>Activities involving disturbance of river or lake beds or the foreshore:</p> <ul style="list-style-type: none"> • Excavations in river beds • Regrading of stream channels • Disturbances of sand dunes or foreshore 	<p>Disturb or deposit any substance on, in, over or under: - the bed of a river or - any foreshore on sea bed</p>	13 12	Land Use Consent Coastal Permit
<p>Placement of structures in riverbeds or coastal marine area:</p> <ul style="list-style-type: none"> • Installation of a new culvert • Culvert replacements, extensions, upgrades • Erosion protection works • Debris retention structures 	<p>Erect, reconstruct, place, alter, extend, remove or demolish any structure in, on, under, or over the bed of - a river, or - any foreshore or seabed</p>	13 12	Land Use Consent Coastal Permit
<p>Stormwater discharges:</p> <ul style="list-style-type: none"> • Discharges of stormwater to land or freshwater bodies including rivers, lakes • Discharges of stormwater to the central marine area 	<p>Discharge of contaminants to land or water Discharge of contaminants to water</p>	15 15	Water Permit Coastal Permit
<p>Maintenance activities:</p> <ul style="list-style-type: none"> • Cleaning debris from culvert inlet/outlet structures • Herbicide spraying • Cleaning or regrading of ditches next to roads • Drain and sump cleaning • Street cleaning 	<p>Disturb or deposit any substance on, in, over or under the bed of a river Discharge of contaminants to air</p>	13 15	Land Use Consent Air Discharge Permit

Permitted Activities

If an activity is permitted under a rule then it is able to be undertaken without the need to submit a consent application *providing* all of the conditions attached to the permitted activity rule (in the plans) are able to be met (Section 3.2.2 in these Guidelines).

If there is any doubt as to whether compliance can be achieved with the permitted activity conditions, or their meaning, it is important to contact the relevant regional council planning department to discuss the matter. It is also important to appreciate that some work may consist of more than one RMA “activity”. For example, installation of a culvert may involve placement of a structure in a streambed, disturbance of the streambed, and diversion of water. Consequently, it is important to dissect a proposed work into its component RMA activities, and to make sure all relevant rules have been identified. Again, professional assistance may be needed.

Regional plans usually contain permitted activity rules for a range of permitted activities that relate to stormwater management. For example, most plans allow the discharge of stormwater (not containing waste or high levels of contaminants) from roads and motorways to watercourses as a permitted activity. District plans may have permitted activity standards for earthworks near a stream or for the “activity” of roading. However, it is easy to be caught out thinking a minor activity is permitted when in fact it is not because of a particular local circumstance, such as the presence nearby of a significant wetland or stream.

It is important to remember that an activity is only permitted if the conditions on the permitted activity rule are met, and in this respect the rule is best thought of as a “mini-consent”. It is therefore essential that contractors are properly briefed about the conditions that must be met to ensure that the works are in compliance with the permitted activity rule.

Activities Requiring Consents

Activities identified in regional or district plans as controlled or discretionary activities require a resource consent from the relevant council (Section 4.2 of these Guidelines).

Once consent needs have been identified, a good idea is to identify at the same time relevant objectives and policies in the plan(s) and any “assessment criteria” referred to in the rules. It is also an appropriate time to identify any relevant sites of “special sensitivity” noted in the plan, such as significant wetlands, native vegetation, outstanding natural features and landscapes, wahi tapu, important public access provisions, etc. This establishes the “planning context” for the consent applications, specifically the matters which will be taken into account by consent authorities when considering the applications (see Section 4.14 of these Guidelines). It also helps to establish what the council is looking for in respect of mitigation, and consequently may provide useful feedback to project design.

Establishment of planning context is therefore a critical stage of project development and one which may be facilitated by having a resource management practitioner prepare an early scoping or “Planning Context Report” in which consent needs, key assessment criteria and policies, and mitigation requirements are identified.

The rest of this chapter provides guidance in relation to the resource consent application process.

4.4 The Global Consent Option

Roading authorities, as part of their strategy for obtaining consents for stormwater management activities, should consider whether a global consent is a regulatory option. (Note, the RMA does not specifically refer to “global consents”.)

A global consent authorises a single activity or a range of activities to take place within an *entire region* or within a *specified part of a region*. The gaining of such a consent removes the need to apply for a large number of individual consents covering the same (low impact) activity/activities at different locations within the region. This results in significant time and cost savings and allows rapid response to management issues as they arise.

In recent years, Transit and TAs have obtained global consents for a range of road management activities including the discharge of de-icing agents onto state highways, bridge and culvert maintenance, the disturbance of streambeds and the discharge of stormwater.

The conditions on a global consent can be tailored to manage or control several activities (if necessary). They can also establish monitoring requirements and provide for review of consent conditions in the same way that any other consent can.

The global consent process is the same as for any other resource consent application (see Sections 4.5–4.15 of this chapter). A resource consent application, including a detailed Assessment of Environmental Effects (AEE), is prepared outlining the specific nature of the proposed works. Generally consent authorities publicly notify these applications, submissions are received, and the application goes to a full council hearing.

4.5 Meeting with Consent Authority

Having identified consent needs, and decided whether or not to apply for several site-specific consents, or a global consent, it is recommended that RCAs then arrange an informal meeting with the relevant consent authority or authorities.

This is not a requirement under the RMA consent process (which is outlined in Section 4.6) but it provides an opportunity to:

- Confirm which activities are permitted activities and to clarify any requirements arising from conditions on permitted activity rules.

- Confirm consent requirements (i.e. the RCA's interpretation of the rules in resource management plans).
- Seek the consent authority's advice on the desirable scope of the AEE (see Section 4.8 of this chapter), consultation needs, key stakeholders, etc.
- Seek the consent authority's advice as to whether any or all of the consents are likely to be handled via the "non-notification" route and, if so, who the authority would deem to be "affected parties" (see Section 4.6).
- Discuss assessment criteria and policy issues arising from plans.
- Discuss mitigation issues.
- Discuss timetable issues.

A record of the meeting should be kept for future reference and it is good practice, after the meeting, for the RCA to write to the consent authority outlining its understanding of the main points arising from the meeting, including consent requirements. This helps to avoid any later misunderstandings.

At this stage, it may be useful for the RCA to consolidate the findings of the Planning Context Report (Section 4.3 above) and the output of the meeting with the consent authority into a "Strategy for the Gaining of Consents". This would among other things present a preliminary scoping of the AEE (i.e. a draft contents page), identify mitigation/design issues, any issues requiring further investigation, key stakeholders, and present a Consultation Plan. This Strategy can be used as a basis for establishing a project budget, providing feedback to the design team, commissioning further work, and taking key decisions about the consultation process.

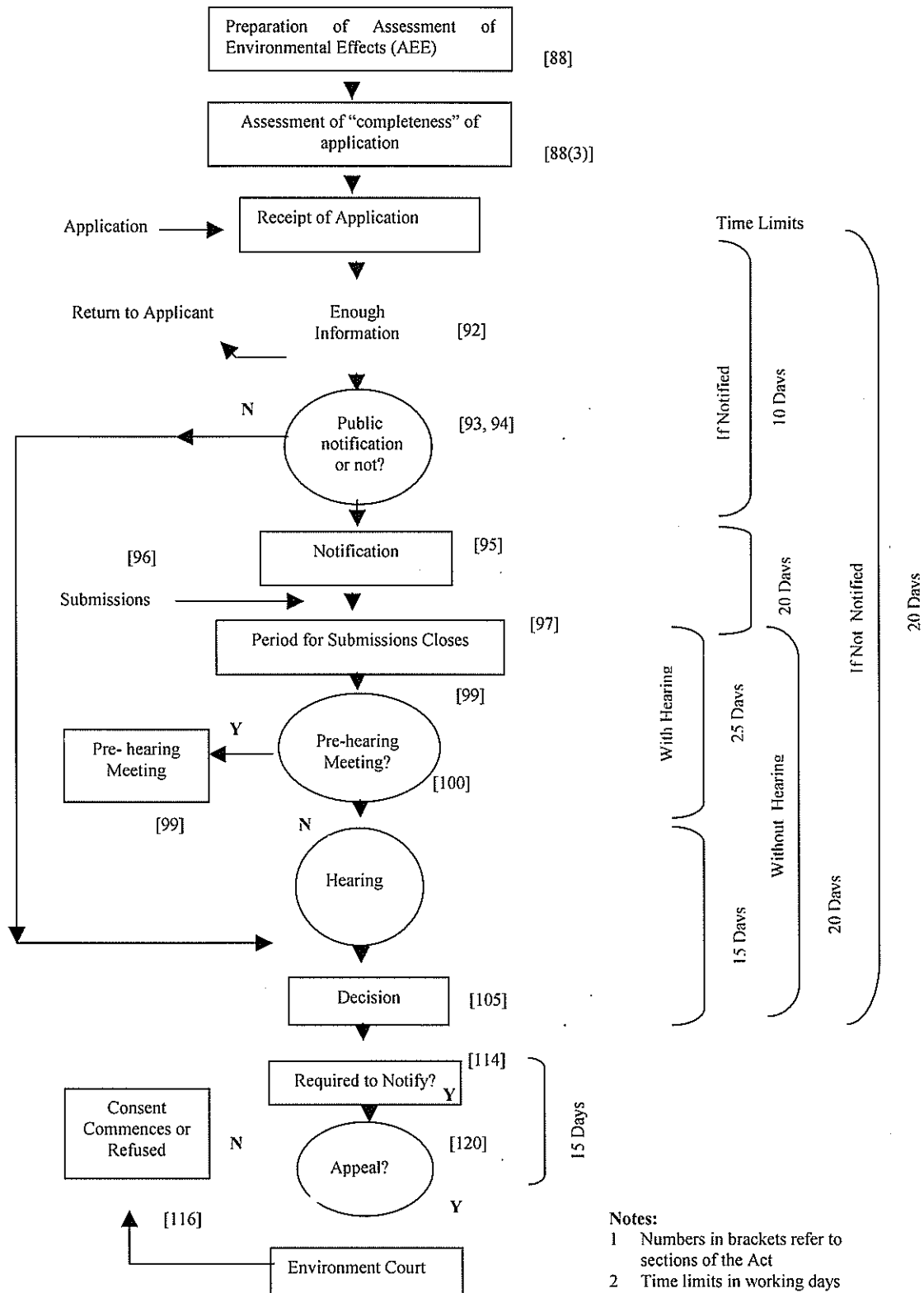
4.6 The RMA Consent Process

The process for the preparing, lodging, and processing of a consent application is set out in sections 88–120 of the RMA 1991, and the key components of the process are summarised in Figure 4.1 of this report.

The RMA sets out statutory time limits for the processing of resource consent applications as follows:

- Lodge resource consent application with relevant authority.
- Council staff consider whether application is "complete".
- Council staff assess the application and determine whether any further information is required, in order for them to fully understand the effects of the proposal (S92 RMA).
- Council determine within *10 working days* of receipt of the application whether to publicly notify the application or not.
- If non-notified, the application should take *20 working days* to process.
- Otherwise, the application is notified with a *20 working day* submission period.
- Council hearing within *25 working days*.
- Council decision within *15 working days* of hearing.
- Appeal period closes *15 working days* after receipt of the decision.

Figure 4.1: Schematic overview of RMA Consent Process.



The general obligation (S21 RMA) of councils is to avoid unnecessary delay. If a council cannot meet the above timeframes, it may invoke section 37 of the RMA which sets out the circumstances under which a council may extend (up to double) the time limits. In practice, it is not possible to force a council to stick to the deadlines.

It is important to note that, following receipt of the application, the Act calls for a decision by the consent authority as to whether or not the application should be *notified* in accordance with section 93 or handled as a *non-notified* application under section 94 of the Act.

The presumption is that all applications are notified unless they meet the specific criteria set out in section 93(1) of the RMA, i.e. the application is for a controlled activity or the adverse effects of the proposed activity on the environment will be minor. If notification is not required, there is a mandatory "limited notification" procedure set out in section 94(1) applying to situations where one or some of the affected parties have not given their written approval to the activity.

Providing that sufficient information has been lodged and that any affected parties have signed Affected Party Approval Forms, decisions on non-notified applications are usually made by council staff under the delegated authority of council. A decision may be issued within 20 working days.

The majority of resource consent applications for general drainage maintenance activities associated with roads, e.g. new culverts, disturbance of a streambed and so forth, are processed as non-notified.

In the case of a *notified* resource consent application, the application is publicly notified, i.e. a notice is placed in the newspaper and a sign put up on the site informing the general public of the proposed activity. A letter and brief description of the proposal is forwarded to all potentially affected parties. Any member of the public has the opportunity to lodge a submission for or against the proposal (not just the directly affected parties) and the council usually decides that a hearing is necessary to consider the submissions. A council officer assesses the application and recommends, in a report to the Hearings Committee (either comprised of councillors or commissioners), that the proposed activity be approved or declined. The Hearings Committee, after hearing the evidence of the applicant and submitter, makes a decision. The applicant and submitters to the application have the right to appeal the decision or conditions of consent to the Environment Court.

The distinction between a non-notified and a notified application is significant, not only because of the potential time delays and additional costs associated with the latter, but also because the likelihood of an application being processed by the non-notification route can affect the RCA's approach to consultation (see next Section 4.7). Hence obtaining an early indication from the consent authority whether an application will be processed as non-notified is important (see previous Section 4.5).

4.7 Consultation

4.7.1 General

Although not formally required under the RMA, consultation with actually or potentially affected parties at an early stage in the development of a project, and as the project unfolds, is recognised as good practice. A number of guidelines have been produced on how to undertake effective consultation¹⁶.

The Environment Court has provided the following definition of consultation:

Consultation involves statement of a proposal not yet finally decided upon, listening to what others have to say, considering their responses and then deciding what will be done.

Consultation is a vehicle for sharing information and ensuring that potentially affected parties are involved in the planning and resource consent processes. It provides a practical means of ensuring that individuals, key stakeholders and interest groups have an opportunity to express their concerns, environmental impacts are identified and, as far as possible, acceptable solutions are found.

In addition to benefiting third parties, early consultation can be of substantial benefit to RCAs because it helps to identify matters that need to be addressed during detailed project design (e.g. avoidance/mitigation of adverse effects), and matters that need to be addressed in the AEE, such as the characteristics of, or values associated with, the proposed receiving environment for a discharge (following Section 4.8). It can also provide an early indication of the likely degree of opposition to a specific proposal from a local community so that other options can be more thoroughly evaluated before more resources are committed to a project that may have a limited likelihood of gaining consents.

4.7.2 Type and Level of Consultation

The type and level of consultation that is desirable depends on the specific circumstances surrounding the project: its size, scale, location, and its potential for adverse bio-physical (ecological) or social effects.

In the case of non-notified activities, where the potential for adverse effects is assessed to be no more than minor, the RCA is required to obtain the written approval of all *affected parties*, so clear identification of those parties and proper consultation with them is essential. For example, consultation for stormwater maintenance works, often treated as a non-notified application, may necessitate a visit to the landowner, phone calls, mail drops and liaison with the local council and Iwi.

¹⁶ Ministry for the Environment (MfE). 1999. *Practice Guidelines on Consultation and Communication for Project Advocates*.
MfE. 2003. *Guidelines for Consulting with Tangata Whenua under the RMA: An Update on Case Law*.
MfE. 2003. *Streamlining RMA Approvals for Land Transport Projects: A Study of Delays in Major Rooding Projects*.

The role of identifying who are affected parties for any given proposal is undertaken by the relevant consent authority, and it is up to the applicant to make the effort to consult with these parties, with the objective of trying to reach agreement and sign-off.

In the case of notified applications (i.e. larger projects and/or projects with the potential to have significant environmental effects), it is recommended that a formal Consultation Plan is developed and that consultation is divided into two phases as set out in the following Section 4.7.3.

4.7.3 Phased Consultation

It is recommended that *Phase I Consultation* includes the development and circulation of an Information Package, including a project description, to all interested parties (not just directly affected parties). It should also include an invitation to provide written or verbal comment on the proposals, identifying any issues of concern and any possible mitigation measures, and indicating whether the parties concerned would like to meet with the RCA and/or its consultants. Contact details (phone, fax, email, mailing address) should be provided.

The gathering of this feedback can be facilitated and standardised by provision of a questionnaire and stamped addressed return envelope.

A record should be kept of any submissions made, meetings held, issues discussed and “preferred solutions”.

It is recommended that *Phase II Consultation* is initiated *after* the preparation of the AEE (see Section 4.9 of this chapter).

4.7.4 Parties to be Consulted

The *interested parties* that need to be consulted during the preparation of a notified application can be quite wide ranging and RCAs should use their own experience, coupled with advice from the consent authority, when drawing up a list of parties to be consulted.

Commonly interested parties or “stakeholders” include the following:

Adjacent landowners

People owning or leasing property adjacent to highways or roads.

Network utility operators

Refer definition of “network utility operator” in section 166 RMA 1991.

Local Authorities

Regional and district councils are not only consent authorities, they can also be major landholders. Councils have many divisions or business units and their interests may be affected by roading and/or stormwater management proposals.

Iwi

The RMA requires councils to take into account the principles of the Treaty of Waitangi. The Act recognises that Iwi have a special cultural and spiritual relationship with the environment which is encapsulated in section 6 of the RMA *Matters of National Importance*, and states “*the relationship of Maori, their culture and traditions with ancestral lands, water, sites, waahi tapu and other taonga*”.

It is recommended that local Iwi are approached at the early stages of designing the project, first as a courtesy so that they are aware of the development, and second to find out if there are any special matters relating to Maori that the RCA should be aware of.

The local regional/district council can provide a list of Iwi contacts for each area.

Department of Conservation (DOC)

DOC staff have detailed knowledge of local conservation values, such as areas that contain rare plants and wildlife. DOC can advise which streams should be avoided at certain times of the year, and how to carry out works in and near waterbodies in an environmentally sound manner. DOC consent is required for activities on DOC land (e.g. conservation estate or reserves).

DOC has powers under the Conservation Act 1987, legislation which has the purpose of promoting the conservation of natural and historic resources. Substantial fines can be levied for discharging or casting any material into freshwater that will adversely affect fish or fish habitats.

DOC has responsibilities under the Conservation Act for freshwater fisheries. The discharge of contaminants into freshwater may be an offence under the Conservation Act (as well as the RMA). If in doubt, call your local DOC office. As with councils, DOC staff appreciate being consulted at an early stage, and can provide useful advice.

New Zealand Historic Places Trust

Where the possibility that a road or associated stormwater management works could affect any historic places or areas, including waahi tapu (Maori sacred sites), then the New Zealand Historic Places Trust should be consulted.

Fish & Game Council

Local Fish & Game officers are another good source of information and advice. They have knowledge of local conservation values, specifically in relation to wetlands and streams. Their interests relate primarily to the maintenance and enhancement of fish and game habitat.

Environmental Groups

Local environment groups often have an interest in the management of stormwater run-off from roads because of the potential effects on native vegetation, wildlife habitat, in-stream values and/or social values. The local Environment Centre or the council will be able to assist with the identification of relevant environment groups.

4.8 Preparation of Draft Assessment of Environment Effects (AEE)

The next step, following Phase I consultation, is to prepare an Assessment of Effects on the Environment (AEE) in accordance with S88 (4) (5) and (6), and the Fourth Schedule, of the RMA. All consent applications must be accompanied by an AEE.

Section 88(6) provides that AEEs are to be in such detail as corresponds with the scale and significance of the actual or potential effects that the activity may have on the environment. The Fourth Schedule outlines the matters that should be included in an AEE.

The contents of the AEE should include:

- A description of the project (including the activities for which consents are sought), the need for it, and proposed timetable.
- An outline of the alternatives considered (if appropriate, see below).
- Clear identification of the consents being applied for.
- A summary of the planning context.
- An outline of the consultation undertaken, the issues raised, and the applicant's response.
- A description of mitigation proposals (see Chapter 5 of these Guidelines).
- A description of (any) monitoring proposals.
- An assessment of the sensitivity of the proposed receiving environment, in the case of proposed discharges of contaminants.
- An assessment of the likely nature of (post-mitigation) environment effects.

Also useful for AEEs to include, as an Appendix, is a set of proposed consent conditions which can incorporate mitigation proposals and which provide a useful basis for discussion or negotiation during Phase II consultation (see following Section 4.9) and at the hearing (Section 4.14 of these Guidelines).

It is recommended that, when deciding the scope of issues to be addressed in the Environmental Effects Section of the AEE, and the emphasis that should be given to each issue, RCAs should draw on the content of the Planning Context Report (Section 4.3), discussions with the consent authority (Section 4.5 of this chapter), issues raised during Phase I consultation, and the matters identified in the Fourth Schedule of the RMA.

If the AEE prepared for the proposed activity identifies a significant adverse effect on the environment, then the AEE will have to address alternative locations or methods for the activity. If the activity cannot be located elsewhere, the reasons why it is necessary to locate the activity at the proposed location should be given.

In preparing an AEE, regard should be had to the definitions of "environment" and "effects" contained in sections 2 and 3 of the RMA, respectively. Various guidelines are available to assist in the preparation of AEEs¹⁷.

¹⁷ MfE. 1999. *A Guide to Preparing a Basic AEE*.

Typically an AEE for a minor stormwater management works, such as placement of a new culvert in a stream, would describe how the works are to be carried out (construction methodology), the level of disturbance to the streambed or stream banks, the “as-built” structure (dimensions, materials), proposed mitigation measures (e.g. sediment control measures, design for fish passage), and the likely post-mitigation effects (e.g. on downstream hydrology, water quality, ecology) during and after construction. The AEE should also outline the positive environmental effects of the proposal, e.g. stormwater control preventing the road from flooding.

An AEE for major works will, of course, be more extensive in its scope and provide much more detail because they will generally have potential for a greater scale of environmental effects, and are likely to be subject to greater scrutiny by the public and the consent authority.

4.9 Phase II Consultation

For the larger projects and/or those with potentially significant environmental effects, that are likely to be treated by the consent authority as a notified applications, holding a second round of consultation is recommended after completion of the draft AEE.

The draft AEE should be made available or sent to all those parties who indicated a desire for ongoing involvement in the project during the Phase I consultation, again with an invitation to provide written or verbal comment and/or to meet with the RCA. The purpose of this Phase II consultation is to identify any outstanding concerns and to attempt to resolve them, before submission of the application, either by way of adjustments to project design or to the proposed consent conditions.

An option to having separate meetings with individual parties is for the RCA to convene a workshop to enable people to work through the issues together, having regard to the range of their interests or perspectives.

A draft AEE can be sent to the relevant council for comment before lodgement. This is generally not necessary for smaller proposals with minor effects, but is recommended for larger scale or more complex projects that may have a range of environmental effects.

In the case of large or potentially high impact projects, particularly where legal issues surround landowner rights and RCA liabilities, it is advisable for the RCA to refer the draft AEE to its legal advisors for comment before releasing it to others.

4.10 Finalisation of AEE and Lodgement of Consent

The AEE can now be finalised having regard to comments received and agreements reached during Phase II consultation, including any comments on the draft AEE from the consent authority, RCA legal advisors, or peer reviewers.

A standard application form is available in the RMA Regulations (Form 9) that covers all consent application types. This form details the minimum level of

information required to be lodged with a council in accordance with section 88 and the Fourth Schedule of the RMA.

In summary, the information required is as follows:

- Name and address of the owner and occupier of any land the proposal relates to.
- The location of the application.
- The type of resource consent sought (land use, discharge or coastal permit).
- A description of the proposed activity.
- The nature of any other consents required by regional or district council.
- The AEE.
- Other information forming part of the application (if any).
- If a subdivision, additional information as required under section 219 of the RMA.

The application should include the signed Written Approval Forms if the RCA wishes to keep open the option of the consent authority handling the application via the non-notification route (see previous Section 4.6). If the RCA is of the opinion that there are no affected parties, it can be helpful to attach a brief section 94 Report with the application outlining the key reasons why it is considered that no parties are adversely affected. This information will assist the council in determining whether the applications should be processed as notified or non-notified.

If a consultant prepares the application, usually their address is used for service and for all correspondence associated with processing the consent application. The applicant's address is also used for any future correspondence from the council once consent has been granted.

4.11 Notification or Non-notification

As indicated in Section 4.6 of this chapter, following lodgement of the application, the consent authority takes a decision under sections 93–94 of the RMA as to whether or not the application is to be handled as a notified or non-notified application.

4.12 Additional Information Requests under Section 92 of RMA

When a council receives a resource consent application, it assesses the information submitted and determines whether it has been supplied with enough information for it to make a full assessment. If, in the council's opinion, there is insufficient information for it to process the application it can, under section 92 of the RMA, put processing of the application on hold, i.e. "stop the clock" with respect to the statutory time limits, and request further information.

When a council invokes section 92 of the RMA, it effectively halts the processing of the application until such time as the applicant forwards satisfactory levels of information.

Section 92 requests are made formally, by letter, specifying the additional information required.

4.13 Pre-hearing Meetings

Following notification of a consent application there is a statutory 20 working days time period, during which interested parties can make submissions in objection or support of the granting of consents.

A pre-hearing meeting (under S99 RMA) is generally held for notified resource consent applications shortly after the submission period has closed. The pre-hearing is an informal meeting facilitated by the council. The meeting allows the applicant and the submitters to get together and, if possible, resolve issues and agree on solutions. This reduces the number of issues that need to be subject to detailed scrutiny at the hearing, and may even result in avoidance of the need for a hearing.

The Ministry for the Environment has published a guide on pre-hearing meetings.

4.14 The Hearing

A hearing is the formal procedure or forum for considering resource consent applications and is called and organised by the consent authority¹⁸. A hearing has to be public and without unnecessary formality. The council has specific powers and duties in relation to hearings, and these are set out in sections 39–42 of the RMA.

In summary, a likely procedure to be followed at the hearing is as follows:

- Council officers (and consultants if applicable) present their reports.
- The applicant presents their case, including calling any witnesses.
- Submitters present their case.
- Council officers have the opportunity to comment on matters raised by the applicant and/or submitters.
- The applicant has the final right of reply.
- The members of the Hearing Committee can ask questions and seek clarification as required. No cross-examination is permitted. However the applicant or submitters can address questions to the members of the Committee of other parties, and the Chairman may or may not re-direct them.
- Hearing Committee retires to deliberate on the application.

The matters which a consent authority must have regard to when considering an application for a resource consent are set out in section 104 of the RMA, and include:

- Any actual and potential effects on the environment of allowing the activities.
- Any relevant provisions of a national policy statement (including the NZ Coastal Policy Statement) or regional policy statement.
- Any relevant objectives, policies, rules or other provisions (e.g. “assessment criteria” contained in rules) of a plan or proposed plan.
- Any other matters the consent authority considers relevant and reasonably necessary to determine the application.

¹⁸ Where a Regional and District Council are both involved, a joint Hearing may be organised by either Party. This saves both time and money. The hearings procedure is identical.

4. Gaining Resource Consents for Stormwater Management

(Note: section 104 should be read in full by the applicant when preparing the application.)

The RMA requires that, within 15 working days of the hearing, the council must release a written decision to the applicant and all submitters.

4.15 Right of Objection

For non-notified applications and notified applications that have not had submissions lodged on them, the applicant alone has the right to object to the council on any of the conditions (S357 RMA). As with notified applications, an objection must be lodged with the council within 15 working days of receiving the decision. The applicant has the opportunity to present their case to the Hearing Committee. The final decision of the Hearing Committee can be appealed to the Environment Court.

4.16 Right of Appeal

The Right of Appeal to the Environment Court extends to the applicant, landowners or any of the submitters. The appeal may be against the decision of the council in principle, or any of the conditions of consent. All that is required is to lodge a Notice of Appeal with the Environment Court and with the Council within 15 working days of receipt of the decision.

The appeal must be in the format specified in Form 7 of the Resource Management Regulations, and a filing fee must accompany the appeal.

Section 121(2) of the RMA and Regulation 11 of the Resource Management (Forms) Regulations set out the procedures to be followed in lodging, serving, timing, etc. that must take place. These provisions must be adhered to or the Court may dismiss the appeal.

4.17 RCA Action following Gaining of Consent

If an RCA has been issued a resource consent for a stormwater management or roading project, the consent will more than likely have a number of conditions attached. It is also quite possible that the applicant will be required to undertake a level of monitoring during and after the construction phase.

It is important that the RCA, as consent holder, reads and understands the conditions of the consent. *As the consent holder is responsible for the consent any consultants or contractors undertaking work for the RCA must also be aware of and understand the conditions of consent.*

Council officers may inspect the project to ensure that the conditions of consent are being complied with. The contractors or consultant may also have to keep records of monitoring activity, or actions taken during the construction phase.

Only the activities that have been applied for, as detailed and described in the resource consent application, can be undertaken. Sometimes a contractor, because of a change of circumstances, may alter the construction methodology or ignore a condition. This will put both the contractor and the RCA in breach of the resource consent and expose them to potential enforcement or court action by the consent authority.

If any changes to the works programme are proposed they must first be “approved” by the relevant council to ensure that the changed programme continues to comply with the resource consent.

5. Environmental Effects and Mitigation Measures for Stormwater Management

5.1 Introduction

Transport activities and the ongoing development of roads and associated run-off have resulted in a variety of changes to New Zealand's waterways. These changes can be broadly grouped into four types: hydrological, physical, chemical, and biological.

Road development contributes to changes in the hydrological regime which can lead to downstream flooding and erosion problems. An altered hydrological regime can also impact directly on aquatic and riparian environments. Similarly, the removal of overhanging vegetation, modifications to streambanks and bed, and the installation of poorly designed culverts can have significant effects on aquatic ecosystems, including fish life.

The road construction phase will often involve vegetation clearance and earthworks which expose soils to erosion by rainfall and stormwater run-off. The mobilisation and transport of sediment can have potentially serious consequences for freshwater and estuarine receiving environments.

Transport activities can make a significant contribution to the loads of chemical contaminants entering urban aquatic environments through emissions to the atmosphere and onto road surfaces. Contaminants which settle on road surfaces are washed by stormwater into nearby water bodies and may accumulate in streams, estuaries, and harbours.

Recent North American research has demonstrated that environmental impairment and loss of sensitive aquatic species can occur when impervious surfaces cover as little as 5-15% of the total catchment area. This compares with typical impervious areas for high density residential, retail/commercial and central business districts of upwards of 40%, 70% and 95% respectively. A significant proportion of these impervious surfaces are roads.¹⁹

The potential environment effects associated with run-off from roads, and potential mitigation measures, are elaborated on in the following sections of this report, and reference is made to relevant documents where appropriate.

5.2 Flooding and Erosion Effects

The development of roadways in New Zealand contributes to the amount of impervious area within a catchment and so reduces the available land into which

¹⁹ Horner, R.R., May, W.M. 1999. Regional study supports natural land cover protection as leading best management practice for maintaining stream ecological integrity. Pp. 233-247 in *Proceedings of the Comprehensive Stormwater & Aquatic Management Conference*, 22-26 Feb 1999, Auckland, New Zealand.

rainwater can infiltrate. Run-off rates from impervious surfaces are much higher than those from vegetated catchments²⁰ and can have dramatic effects on stream hydrographs. The increased risk of flooding is often mitigated by engineering solutions (such as channelisation), which in turn increase the hydraulic efficiency of the waterway and hence the rate of run-off and the magnitude of peak flows.

Roadway development thus has the potential to cause downstream flooding and erosion problems which previously did not exist, with significant social and economic consequences. Flooding and erosion may also have significant implications for stream ecology as discussed below.

Management Implications (Mitigation)

New roadways, and urban development generally, can and should be designed to minimise increases in stormwater run-off rates. A combination of structural control and source-control methods can be employed.

Structural control or management involves construction of detention dams or other structures that are designed to attenuate the peak flows in flood events. Collected run-off is then released gradually into the stream over time.

Source-control or non-structural management is aimed at reducing the amount of run-off that enters urban streams rather than attenuating flood peaks. This strategy generally integrates stormwater management into the design criteria for new urban development. It centres on reducing the proportion of impervious surfaces and reducing stormwater run-off rates. There is increasing interest in non-structural techniques as methods of both reducing the rate of run-off and removing contaminants at source (see Section 3.3.6 for discussion of SUD techniques).

Source control methods are addressed in the Auckland Regional Council's *Low Impact Design Manual*,²¹ which includes a particular focus on the design of roads, kerbing, turnaround areas, parking, driveways and footpaths with a view to reducing the total area of sealed surface. Minimising site disturbance and the use of vegetated filter strips, infiltration trenches, porous pavements, vegetated swales and constructed wetlands can also play a role in slowing stormwater flows, reducing run-off volume and contaminant removal (see Section 5.3.1 and Chapter 6 of these Guidelines).

5.3 Effects on Aquatic Ecosystems

5.3.1 Effects Arising from Changes to Flow Regimes and Stream Habitats

Physical changes made to the channels of many urban streams, to improve their capacity to drain stormwater or to otherwise facilitate urban development (including roading development), have substantially altered, and in some cases completely

²⁰ McConchie, J.A. 1992. Urban Hydrology. Pp. 335-364 in: Mosley, M.P. (Ed.) *Waters of New Zealand*. New Zealand Hydrological Society Inc., Wellington.

²¹ Auckland Regional Council. 2000. *Low Impact Design Manual for the Auckland Region*. ARC Technical Publication No. 124.

destroyed, the aquatic life originally present. These changes include removal of overhanging vegetation, replacement of the natural streambanks and beds with hard protective structures, and enclosure of streams in pipes and culverts.

As urban development proceeds, the proportion of impervious surface, such as roofs, roads, footpaths and car parks, in a catchment increases. This reduces the infiltration of rain into the soil and increases the rate of delivery of water to the stream. Straightening and realignment of natural channels may be undertaken to increase hydraulic efficiency in times of flood so that stormwater is quickly and efficiently transported to the sea. Stream power is often increased in such modified streams, and bank destabilisation and erosion are a common consequence. To minimise such erosion, traditional engineering practices have relied on reinforcing streambanks with wood or concrete which greatly reduces their spatial heterogeneity.²²

Naturally meandering channels typically have complex morphologies that produce eddies and areas of low velocity. These areas can act as refugia for invertebrates and prevent them from being washed away during times of high flow.²³ Reinforced channels such as concrete culverts offer little structural complexity, so that few areas of low velocity are present during floods. High velocities over smooth concrete channels will scour away most invertebrates. Under such conditions only a very limited range of small invertebrates can be sustained.

With the rapid run-off of stormwater, infiltration to land is reduced and much less groundwater is available to maintain stream flow between storm events. Peak flows are therefore higher and base flows are lower than in the natural state. Streams dry up more frequently and habitat is lost. Higher stream temperatures occur because of lower base flows and reduced vegetation cover, and this further reduces habitat quality.

Management Implications (Mitigation)

The physical changes in urban streams can reduce the quality and availability of aquatic habitat, reduce biodiversity and may have significant adverse effects on aquatic ecosystems. These effects can, however, be avoided, mitigated or remedied by designing drainage works and conduits to be more in harmony with natural drainage systems, with the objectives of retaining or reinstating moderately stable unmodified banks, well developed riparian vegetation, a moderate supply of stream organic material from terrestrial plant leaf fall, a relatively natural flow regime, and diversity in channel widths, depths and velocities.^{24, 25, 26}

²² Suren, A. 2000. Effects of urbanisation. Pp. 260-288 in: *New Zealand stream invertebrates: ecology and implications for management*. New Zealand Limnological Society, Christchurch.

²³ Winterbottom, J., Orton, S., Hildrew, A., Lancaster, J. 1997. Field experiments on flow refugia in streams. *Freshwater Biology* 37: 569-580.

²⁴ Williamson, B. 1999. Broad-scale assessment of urban stormwater issues in the Waikato Region. *NIWA Client Report EVW90213*, prepared for Environment Waikato.

²⁵ Suren, A., Snelder, T., Scarsbrook, M. 1998. Urban Stream Habitat Assessment method (USHA). *NIWA Client Report CHC98/60*, prepared for MfE and others.

²⁶ Suren, A., Snelder, T., Scarsbrook, M. 1999. Urban Stream Habitat Assessment method: a management tool for resource managers. Pp. 129-137 in *Proceedings of the Comprehensive Stormwater and Aquatic Management Conference, 22-26 Feb 1999*. NZWWA Auckland.

Strategies for restoring flow regimes have been outlined in Section 5.2. Refer also to Section 3.3.6 of these Guidelines for discussion of SUD techniques.

5.3.2 Effects of Structures on Fish Passage

New Zealand possesses a relatively sparse freshwater fish fauna, with only 35 or so indigenous species, at least another 20 introduced, and half a dozen marine wanderers which periodically enter estuaries and lowland rivers. Of the 35 indigenous freshwater species currently recognised, 18 are diadromous, i.e. undergo migrations between fresh and saltwater as a necessary part of their life cycle. Fish passage is therefore a significant issue in New Zealand as inadequately designed in-channel structures can prevent passage of migrant fish.

Single or multi-barrel culverts are often the preferred means of building roads over the numerous small waterways in New Zealand. Traditionally, culverts have been installed with a focus on their hydraulic capacity, and it is only relatively recently that proper consideration has been given to the needs of fish passage.

Other structures such as weirs, fords and bridge aprons may also interfere with fish passage.

Consents are required from regional councils for the construction of culverts or other in-river structures unless the activity is permitted by a rule in a regional plan. Where any structure will create a barrier to fish migration, an approval or dispensation is required from the Director-General of Conservation under the Freshwater Fisheries Regulations (1983).

Management Implications (Mitigation)

Boubee et al.²⁷ provides a comprehensive review of information on fish passage at culverts. This is a key reference which makes recommendations on the proper design of culverts in New Zealand (including culvert alignment, culvert width, invert level, inlet types, gradient, surface roughness, multiple barrels and light requirements).

A pamphlet produced by Cawthron Institute²⁸ entitled *Fish Passage in New Zealand Waterways* provides useful design advice for ensuring that man-made structures in waterways do not prevent fish from reaching their habitats.

Refer also to Chapter 4 of these Guidelines (Gaining Resource Consents) and Section 6.6 (Drainage Systems).

5.3.3 Effects of Sedimentation on Aquatic Ecology

Road construction activities, including vegetation clearance and earthworks, can potentially result in accelerated on-site erosion and greatly increased sedimentation of waterways. The concern relates primarily to the volume of sediment that can be

²⁷ Boubee, J., Jowett, I., Nichols, S., Williams, E. 1999. *Fish passage at culverts: A review, with possible solutions for New Zealand indigenous species*. Prepared for NIWA (National Institute of Water & Atmospheric Research) and Department of Conservation.

²⁸ Cawthron Institute. 2000. *Fish passage in New Zealand waterways*. Cawthron Institute Pamphlet [online].

eroded and mobilised by stormwater, with its potential to modify aquatic habitats and reduce the life-supporting capacity of streams and estuaries. Suspended solids are “contaminants” for the purposes of section 15 of the RMA for Discharge of contaminants (see Section 4.3, Table 4.1 of these Guidelines).

Suspended solids can reduce primary production and invertebrate food quality, increase scouring effects on stream biota, accelerate in-filling of interstitial spaces, smother the streambed, and reduce spawning success and feeding efficiency of fish.^{29,30}

In post-construction, once the site works and re-vegetation programme have been completed, the rate of sediment erosion is much reduced, and typically sediment loads delivered to waterways from sealed road surfaces are low. However, after sealing, the composition of particulate material carried by stormwater run-off then changes from a predominantly soil-based material to one derived largely from motor vehicle emissions and wear and tear. Contaminants derived from these sources often become physically or chemically bound to sediment particles. The issue then becomes one of sediment quality rather than quantity. Chemical contamination of sediments and water is discussed in Section 5.3.4 of this report.

Management Implications (Mitigation)

Erosion and sediment control issues have been comprehensively addressed in various guideline documents. Key references include Auckland Regional Council’s (1999) *Guidelines for Land Disturbing Activities*³¹ and Transfund New Zealand’s *Provisional Guidelines for Erosion and Sediment Management During Road Works*³². Refer also to design considerations discussed in Section 6.7 of these Guidelines.

5.3.4 Chemical Contaminants in Road Run-off

Studies in New Zealand and overseas have identified urban run-off as a major contributor to the declining quality of aquatic environments. It is estimated that upwards of 40% of the contaminant content of this run-off can be attributed to run-off from roads.^{33, 34}

²⁹ Ryan, P.A. 1991. Environmental effects of sediment in New Zealand Streams: A review. *NZ Journal of Marine & Freshwater Research* 25: 207-221.

³⁰ Quinn, J.M. 2000. Effects of pastoral development. Pp. 208-229 in: *New Zealand Stream Invertebrates: Ecology and implications for management*. New Zealand Limnological Society, Christchurch.

³¹ Auckland Regional Council (ARC). 1999. Erosion & sediment control guidelines for land disturbing activities. *ARC Technical Publication No. 90*.

³² Montgomery Watson NZ Ltd. 1999: Environmental management for roading contractors II. Provisional guidelines for erosion and sediment management during road works. *Transfund New Zealand Research Report No. 131*. 34pp.

³³ Babich, J., Lewis, G. 2001. Contaminant loadings in stormwater run-off and wastewater overflows: A Waitakere City case study. In *Proceedings of 2nd South Pacific Stormwater Conference*, 2001.

³⁴ Lau, S., Stenström, M.K. 2001. Metals and PAH adsorbed to street particles. In *Proceedings of 2nd South Pacific Stormwater Conference*, 2001.

The sources of contaminants from roads fall into six main groups, namely vehicle exhaust emissions, tyre wear, brake lining wear, transport fuels, lubricant losses, and road surface wear.

- Vehicle exhaust emissions contain a wide range of metals and organic compounds. In terms of the road corridor, it is the particulate component of the emissions that is most important. The particulates from diesel-fuelled vehicles are important contributors of polycyclic aromatic hydrocarbons (PAHs).
- Tyres are an important source of zinc and possibly lead within the road catchment. Tyres also contain a range of organic compounds.
- Brake pads are an important source of copper, lead and antimony. They also contain a number of organic compounds.
- Vehicle fuels contain a wide range of volatile organic compounds (VOC), semi-volatile organic compounds (SVOC) and metals. However fuel losses are probably not a significant factor in the overall load of contaminants that enter stormwater and are generated by motor vehicles.
- Vehicle lubricants, greases and coolants contain a range of metals, in particular zinc, and a range of organic compounds. However in most cases, the sources are contained and they probably do not provide a significant source of contamination to the road stormwater system.
- Road surface wear is a source of particulate matter and some organic compounds. Bitumen surfaces contain PAHs in low concentrations.

5.3.5 Chemical Contamination of Urban Streams

Transport-derived contaminants from oil leaks, brake linings, tyre wear and road wear accumulate on road surfaces and are added to by deposition of air-borne particulate materials from vehicle emissions. When rain falls these materials are washed from the road surface into the stormwater system and then into receiving environments such as streams, estuaries and harbours.

The concentrations of metals and other contaminants in New Zealand urban stormwater have been reported in several studies.^{35,36,37,38} However, few of these studies have focused specifically on roadway stormwater run-off and, for those that have, the data is limited (Table 5:1).

³⁵ Williamson, R.B. 1985. Urban Stormwater Quality 1: Hillcrest, Hamilton, New Zealand. *NZ Journal of Marine and Freshwater Research* 19(3): 413-427.

³⁶ ARC. 1992. An assessment of stormwater quality and the implications for the treatment of stormwater in the Auckland Region. Prepared by Kingett Mitchell and Associates. *ARC Technical Publication No. 5*.

³⁷ Williamson, R.B. 1993. Urban Run-off Data Book: A manual for the preliminary evaluation of urban stormwater impacts on water quality. *NIWA Water Quality Centre Publication No. 20*.

³⁸ Sherriff, J. 1998. An investigation into the water quality effects of transport. *Wellington Regional Council Publication WRC/RINV-T-98/25*.

Table 5.1: Summary of trace elements and PAH concentrations in urban and motorway stormwater in New Zealand.

Source	Location	ADT	SS g/m ³	Cd	Cu	Cr	Pb	Ni	Zn	Total PAH	N
Urban											
Williamson (1985) ³⁵	Hillcrest		–	<5	23	<3.4	95	40	190	–	16
Williamson (1993) ³⁷	NZ-wide		170	–	40	–	110	–	260	–	–
ARC (1992) ³⁶	Pakuranga		17	0.056	15	–	55	–	444	–	28
	Southdown		52	–	42	37	82	–	446	–	42
Motorway											
ARC (unpublished)	Otahuhu	90,000	91.4	–	53	–	108	–	159	15.6	60
Sherriff (1998) ³⁸	Porirua	50,000	–	<5	80	<30	<50	<30	60	308	30
ANZECC (2000) trigger levels for aquatic ecosystems				0.2	1.4	1	3.4	11	8	n.a.	

All results are median values (mg/m³ unless otherwise stated)

ADT = average daily traffic

SS = Suspended solids

N = number of samples

PAH = polycyclic aromatic hydrocarbons

Table 5.1 indicates that contaminants generated by transport activities can enter urban streams at much higher concentrations than ANZECC (2000) trigger levels³⁹ for the protection of aquatic ecosystems. The trigger levels were calculated on the basis of protecting 95% of the species likely to be present in receiving waters. This is considered to be an appropriate level of protection for slightly to moderately disturbed ecosystems.

In urban areas where a large proportion of the catchment is impervious, and much of the stream flow is derived from urban run-off, adverse effects on stream biota are likely.^{40,41,23} Copper, lead and zinc are the metals of potentially greatest concern in urban streams. PAHs are also known to be important contaminants in stormwater and urban streams.⁴

However, neither the scale nor the significance of this contamination problem is well defined in New Zealand. Information about the distribution of these contaminants within waters and sediments of particular streams and estuaries is scarce. As well, the bio-availability of contaminants within a particular receiving environment is not fully understood and the magnitude of the effects on aquatic ecosystems is not known.

A NIWA research programme is currently focusing on the effects on urban aquatic ecosystems of transport-generated contaminants. This research aims to address some of the knowledge gaps outlined above. Preliminary results were presented at NIWA's Stormwater and Transport (SWAT) workshop in July 2000, and at a Roding and Stormwater Technical Workshop in May 2002.

³⁹ ANZECC. 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council.

⁴⁰ Hickey, C.W., Clements, W.H. 1998. Effects of heavy metals on benthic macroinvertebrate communities in New Zealand streams. *Environmental Toxicology and Chemistry* 17: 2338-2346.

⁴¹ Crunkilton, R., Kron, D. 1999. Assessing the effectiveness of a pilot scale wet detention basin in reducing toxicity of urban run-off. *Proceedings of Comprehensive Stormwater and Aquatic Ecosystem Conference, Auckland, 22-26 February, 1999*.

One component of the research programme is aimed at determining levels of “continuous” or chronic exposure of stream animals to dissolved and particulate contaminants.^{42,43} The preliminary results for a range of streams in residential, commercial and industrial catchments indicate that:

- Contaminant concentrations are typically very high during the early stage of stormflow (around 10-1000 times the base-flow concentrations), but those high concentrations occur for only short periods of time.
- Zinc is the dissolved metal of most concern, with *base-flow* concentrations usually exceeding ANZECC (2000)³⁹ trigger levels, and possibly affecting up to 15% of aquatic organisms that could inhabit urban streams. (This assessment is based on “no-observable effect” levels from a compilation of chronic toxicity data for zinc and aquatic organisms). The effects of *peak stormflow* concentrations of zinc are not yet known, but it is reasonable to assume that the high transient stormflow concentrations would add to the stress.
- Dissolved copper base-flow concentrations are typically close to ANZECC (2000)³⁹ trigger levels. Few aquatic organisms are likely to be affected by base-flow copper concentrations, but high transient stormflow concentrations increase the risk of adverse effects.
- The concentrations of copper, lead and zinc in fine suspended particulate matter are often very high. Concentrations of these metals in fine particulate material trapped in biofilms (filamentous algae and brown diatom cover on streambed surfaces) can also be high. Biofilms are the food of invertebrate grazers such as snails. Ingestion of this particulate matter by grazing animals increases their dietary exposure to these metals.

Of the three common metal contaminants in urban stormwater and stream water, zinc and copper are essential in small amounts for healthy bodily functioning. The body burden of these metals is controlled by an animal’s ability to excrete any metal taken up in excess of requirements. Under normal levels of dietary exposure this mechanism maintains the body burden within the required ranges. If, however, the amounts taken up exceed the amount that can be excreted, then the body burden increases until there is a toxic effect.

Lead on the other hand, is not essential for animal growth and, in fact, it is a potent toxin. Mechanisms for controlling the body’s burden of lead are not as efficient as are those for copper and zinc. Consequently, lead tends to accumulate and the body burden increases with uptake.⁴⁴

⁴² Timperley, M. 2000. Chemical contamination of urban streams. NIWA presentation to *SWAT Workshop*, Hamilton 26-27 July, 2000.

⁴³ Timperley, M. 2002. Urban contaminants research: transport-streams-estuaries. NIWA presentation to *Road and Stormwater Technical Workshop*, Wellington 6-7 May, 2002.

⁴⁴ Timperley, M.H., Golding, L., Webster, K.S. 2001. Fine particulate matter in urban streams: is it a hazard to aquatic life? Pp. 135-141 in *Proceedings of 2nd South Pacific Stormwater Conference*, 2001.

Before 1996, leaded petrol was a major source of lead in stormwater. The lead concentration in road dust collected in about 1990, from Pakuranga (Manukau City), ranged from 720 mg/kg to 2524 mg/kg.⁴⁵ Concentrations measured in the material washing off an arterial road in Avondale in 1999 (see NIWA research below) ranged from 360 to 2280 mg/kg. These concentrations are not that much different despite the 3 years since the use of leaded petrol was discontinued. Lead will continue to be a significant hazard for urban stream and estuary ecosystems for some time yet. It is suspected that brakes and tyres are now the main sources, but this is the subject of further research by NIWA.

The NIWA research has a specific focus on transport effects on aquatic ecosystems.⁴⁶ Field studies were undertaken at a test site in Avondale in Auckland where all the stormwater from a known area of road surface drains through a single stormwater system. Monitoring of contaminant concentrations in stormwater through a series of rainfall events in 1999 has enabled the calculation of a contaminant loading per vehicle. By applying this loading factor to the number of vehicle-kilometres driven, it was estimated that motor vehicles in Auckland City emitted 190 kg copper, 682 kg zinc, 353 kg lead, 1.5 kg PAH, and 20,544 kg TPH (Total Petroleum Hydrocarbons) to urban waterways in 1999.

These are interim results only, but NIWA proposes further monitoring at a new monitoring site in Richardson Road, Auckland City.

Management Implications (Mitigation)

The evidence for chemical contamination and ecological degradation of urban streams both in New Zealand and overseas is unequivocal. Furthermore, contaminant input from roadway run-off can be significant, and has probably contributed to the loss of sensitive aquatic species in many urban streams. However, other factors such as changes to the flow regime and loss of habitat quality can also have a significant effect, and it is often difficult to establish precise cause-effect relationships.

The degree and type of stormwater treatment that is justifiable will vary from catchment to catchment. It will depend on a number of factors including the intensity of traffic use and the sensitivity of the receiving environment. The indicative performance of various treatment devices is summarised in Table 5.2.

Descriptions of these stormwater treatment systems and design considerations are given in Section 6.8 of this report.

⁴⁵ Kingett Mitchell and Associates. 1992. *An assessment of stormwater quality and the implications for treatment of stormwater in the Auckland region*. Report prepared for the Environment and Planning Division, Auckland Regional Council.

⁴⁶ Kuschel, G. 2000. *Transport effects on aquatic ecosystems*. NIWA presentation to SWAT Workshop, Hamilton 26-27 July, 2000.

Table 5.2: Approximate percentage contaminant removal efficiency of various stormwater treatment devices

(from Hartwell 2002⁴⁷, Ellis 1999⁴⁸, Earles et al. 1999⁴⁹)

Contaminant	Enviro-pod	CDS unit	Rock filter	Sand filter	Grassed swales	Ponds	Porous pavement	Rain garden	Wetland
Suspended solids	66	66	81	81	62	73	70	80	90
BOD5	23	23	35	35	23	35	35	35	–
Total Phosphorus	15	15	70	70	45	60	60	81	70
Total Copper	41	41	60	61	37	55	80	93	–
Total Lead	50	50	76	76	67	67	80	99	69
Total Zinc	49	49	75	75	63	51	80	99	62
Total Kjeldahl N	11	11	45	32	45	60	80	68	53
TPH	10	10	80	80	75	20	20	80	–
E.coli	0	0	37	37	0	75	15	37	–
Enterococci	0	0	37	37	0	75	15	37	–
Faecal coliforms	0	0	37	37	0	75	15	37	88

5.3.6 Metal Bio-availability and Toxicity in Urban Streams

Metals are present in a variety of forms in freshwaters. They may be contained within organic or inorganic complexes; adsorbed to sediments, plants and suspended material; or in solution as “free” metal ions. Irrespective of the form in which metals are present, they are only a concern if they are able to interact with the organisms present. This requires a mechanism for metal transport through the cell membrane, or for interfering with normal cell function from outside the cell.

Only free metal ions (e.g. Cu^{2+} and Zn^{2+}) are bio-available, and can form the cell surface metal complexes necessary for the transport of the metal through the cell wall into the cell interior. Therefore, of all the forms of metal present in the freshwater environment, only the free metal ions are potentially toxic to aquatic life.

Preliminary research undertaken by NIWA⁵⁰ shows that, for a range of urban streams surveyed, copper concentrations are close to ANZECC (2000)³⁹ guideline values, but in the downstream parts of these stream systems all of the dissolved copper is complexed by dissolved organic matter, and is therefore not bio-available.

The results for zinc were quite different in that dissolved concentration tended to be relatively high, and were consistently well in excess of the zinc-complexing capacity of the water.

⁴⁷ Hartwell, S., Reid, P. 2002. *Waitakere City Roding Stormwater Strategy*. Presentation to *Roding and Stormwater Technical Workshop*, Wellington, 6-7 May 2002.

⁴⁸ Ellis, B.J. 1999. Vegetative discharge systems for highway discharges: design and operation. *Proceedings of Comprehensive Stormwater and Aquatic Ecosystem Conference*, Auckland, 22-26 February 1999.

⁴⁹ Earles, T.A., Fitch, G.M., Yu, L.Y. 1999. Field monitoring of constructed wetlands receiving highway run-off. *Proceedings of Comprehensive Stormwater and Aquatic Ecosystem Conference*, Auckland, 22-26 February 1999.

⁵⁰ Webster, K. 2000. *Predicting metal bio-availability*. NIWA presentation to *SWAT Workshop*, Hamilton, 26-27 July, 2000.

The ability of stormwater and stream waters to complex metals is related to their dissolved organic carbon (DOC) content, however the results of this study suggest that the composition of the DOC is the controlling factor. In particular DOC derived from decaying plant material, which was the predominant form in the lower part of the surveyed streams, may have a stronger affinity for metals than DOC derived from other sources. The ability of different leaf extracts to complex metals (e.g. those from *Pittosporum*, cyprus and mahoe) is the subject of further NIWA research.

Initial research into the capacity of leaf leachate to bind with PAHs, and in particular fluoranthene, indicates that binding is relatively weak and that little reduction in toxicity occurs.⁵¹

Management Implications (Mitigation)

In addition to the well-established ecological benefits of riparian vegetation for streams – including its function as a buffer to bank erosion, a buffer to inputs of nutrients and other contaminants in overland flow, a de-nitrifier of groundwater, maintainer of microclimate (light, temperature, humidity), and provider of terrestrial carbon inputs in the form of leaf litter – it also appears to have (as leaf litter is an important source of dissolved organic carbon) the potential to reduce the bio-availability of some metals, and so reduce the toxicity of contaminated stormwater inflows.

A riparian planting programme would normally be required as part of the reinstatement or restoration of watercourses associated with roading development projects. Consideration should be given to the selection of an appropriate mix of species to meet a range of ecological and water quality objectives,⁵² including the reduction of contaminant bio-availability in stream water.

5.3.7 Contaminant Accumulation and Effects in Estuaries

Stormwater from New Zealand's urban areas typically is discharged, either directly or indirectly, to harbours, estuaries or sheltered coasts. In Auckland the receiving environment is commonly the estuarine arms of the Waitemata and Manukau Harbours. The prediction of contaminant accumulation in urban estuaries is therefore an important focus of the NIWA research.⁵³

Analyses of dated sediment profiles in Pakuranga Estuary show relatively low metal concentrations before 1950, then a rapid increase through the 1950s as use of existing roadways and urban areas intensified. Concentrations have generally continued to increase through to the present (Figure 5.1).

Contaminants accumulate in sheltered sub-estuaries because these depositional receiving environments trap fine particulates, and fine particulates tend to adsorb

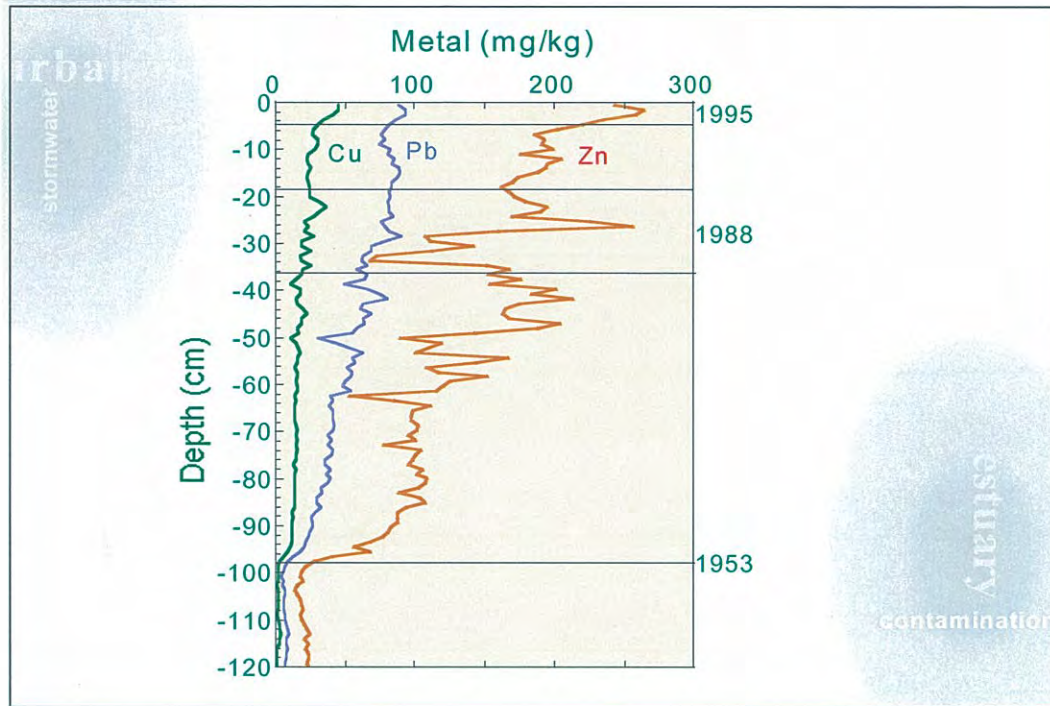
⁵¹ Mills, G. 2000. *Reducing the toxicity of organic contaminants in urban streams*. NIWA presentation to *SWAT Workshop*, Hamilton 26-27 July, 2000.

⁵² Collier, K.J., Cooper, A.B., Davies-Colley, R.J., Rutherford, J.C., Smith, C.M., Williamson, R.B. 1995. *Managing riparian zones: A contribution to protecting New Zealand's rivers and streams*. Department of Conservation, Wellington, New Zealand.

⁵³ Williamson, B. 2000. *Predicting contaminant accumulation in urban estuaries*. NIWA presentation to *SWAT Workshop*, Hamilton, 26-27 July, 2000.

contaminants such as zinc, copper and lead. The distribution of zinc in Pakuranga Estuary, which drains Howick and Pakuranga, is shown in Figure 5.2. High concentrations occur near sources (urban streams) at the head of the estuary.

Figure 5.1: Contaminant concentrations in sediment profiles taken in Pakuranga Estuary (from Williamson 2000⁵³).



It is reasonable to assume that the recorded increase in concentrations of copper, lead, zinc and PAH in Auckland estuaries is associated with the expansion of motoring, the use of leaded petrol, and improvements in stormwater drainage efficiencies. These developments began increasing in the late 1940s, and before that, industrial run-off and discharges would have dominated contamination.

Model predictions for zinc concentrations in surface sediments of Pakuranga Estuary are shown in Figure 5.3. The model shows zinc starting to increase in about 1950, and by about 1987 concentrations exceed the sediment quality guideline of Effects Range-Low (ER-L).⁵⁴ Above this concentration biological effects may begin to occur (i.e. some animals in or on the sediment may begin to be affected by the zinc). By 2020, concentrations are predicted to exceed the sediment quality Effects Range-Medium (ER-M), above which a significant number of animals are expected to be affected.

⁵⁴ Long, E.R., MacDonald, S.L., Calder, F.D. 1995. Incidence of adverse effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* 19(1): 81-97.

Figure 5.2: Spatial distribution of surface sediment zinc concentrations in Pakuranga Estuary (from Williamson 2000⁵³).

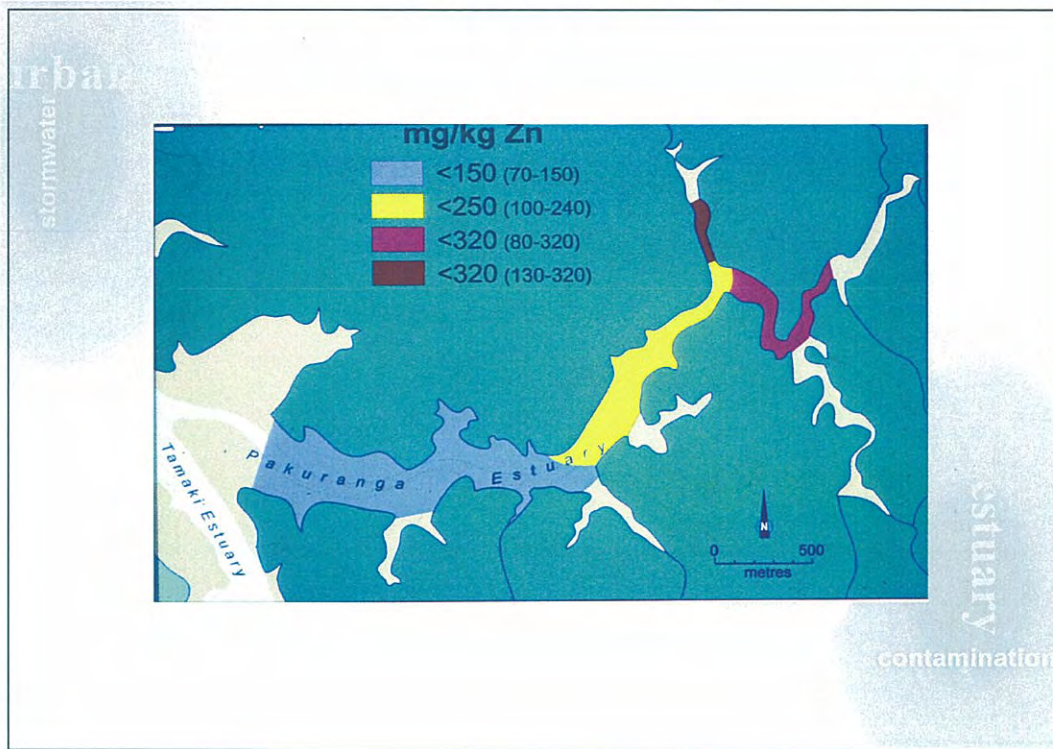
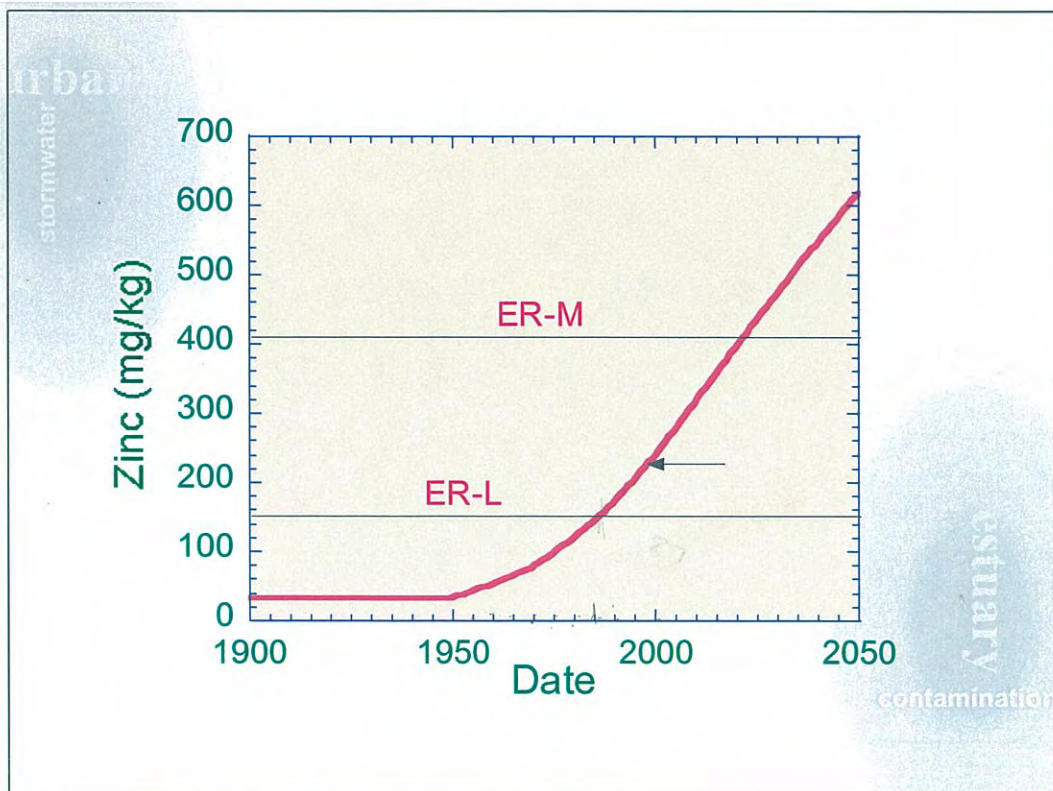


Figure 5.3: Model predictions for zinc concentrations in Pakuranga Estuary sediments (from Williamson 2000⁵³).



ER-L = Effects Range-Low
 ER-M = Effects Range-Medium

The model prediction for copper is that concentrations will increase but at a lower rate than for zinc. Lead concentrations are predicted to decline slowly because lead is no longer used as a petrol additive. PAH concentrations are predicted to increase gradually, although there is also evidence of declining concentrations in Manukau harbour sediments.⁵⁵

The significance of contaminant accumulation in these receiving environments can best be assessed with an integrated approach, utilising sediment quality guidelines, biological surveys and toxicological studies. Work in these areas is not yet sufficiently advanced to enable a clear assessment of the effects of transport on estuarine and coastal ecosystems. Nevertheless the following conclusions can be drawn from NIWA's research to date in the Pakuranga Estuary:

- (i) stormwater contamination is a relatively new form of pollution;
- (ii) biological effects are small at present;
- (iii) contamination of estuaries will continue to increase and, in the case of zinc, sediment quality guideline "probable effects" levels will be exceeded within a matter of decades.

Management Implications (Mitigation)

In the absence of settling devices, such as sedimentation ponds, catch pit filters, etc., in urban catchments, both coarse and fine sediments reach estuaries. Thus, in estuarine bed sediments, the highly contaminated fine particulate matter is diluted by the less contaminated coarse sediment. With the installation of sediment retention devices, however, the sediment reaching the estuary is mostly fine particulate matter. Although these devices can reduce estuarine sediment deposition rates, they can also cause estuarine bed sediments to become more muddy and enhance the rate at which contaminant concentrations are increasing.

In situations where the removal of fine particulate material is an important objective, the selection of a constructed wetland system, possibly in conjunction with other devices such as detention ponds or grassed swales, is likely to perform well. A constructed wetland typically comprises two cells or zones, an open water inlet zone and a macrophyte zone.⁵⁶ Soluble pollutants and fine particulate material are taken up by epiphytic biofilms which are supported by the macrophytes. A possible alternative to a wetland is a shallow macrophyte pond, which might have some advantages in terms of maintenance and hydraulics of the system.⁵⁷

In less intensively developed urban areas the use of a high performance system (e.g. detention pond and wetland) may not be justified and other methods may be more appropriate. Section 6.8 (Stormwater treatment system design) of these Guidelines deals with these in detail.

⁵⁵ Mills, G. 2000. *PAHs in NZ estuaries: are they a problem?* NIWA presentation to *SWAT Workshop*, Hamilton, 26-27 July, 2000.

⁵⁶ Wong, T., Breen, P.F., Somes, N., Lloyd, S.D. 1998. Managing urban stormwater using constructed wetlands. *Industry Report 98/7, Cooperative Research Centre for Catchment Hydrology*.

⁵⁷ Leersnyder, H. 1993. *The performance of wet detention ponds for the removal of urban stormwater contaminants in the Auckland (NZ) region*. MSc thesis, University of Auckland.

5.4 Effects on Recreational and Amenity Values

Until relatively recently, most urban and road run-off management has focused on flood control and the maintenance of hydraulically efficient drainage channels. This has led to a proliferation of highly modified urban waterways in which the progressive loss of ecological values is paralleled by a deterioration of recreational and amenity values.

Management Implications (Mitigation)

The recreational and general amenity values of rivers and streams are closely aligned to the ecological integrity of those water bodies. Measures which reduce stormwater run-off volumes and contaminant levels, and/or which restore key habitat quality variables – such as riparian vegetation, a natural flow regime, and relatively unmodified banks – will tend to preserve or enhance recreational opportunities and amenity values. The benefits of managing urban streams as entire ecosystems are evident in Christchurch where the City Council has encouraged the development of riparian reeds, grasses and sedges along urban streams. This strategy provides cover and new habitat for fish, invertebrates and birds, while enhancing the aesthetic appeal of waterways.

See Section 3.3.6 of this report for discussion of SUD techniques.

5.5 Effects on Cultural Values

From a Maori cultural perspective, the discharge of contaminants (sediment or chemicals) to water bodies equates with a loss of *mauri* or spiritual life force of the water body concerned.

Some waterways or coastal marine areas are more important than others to iwi for either historical or spiritual reasons or because they have been used as traditional food sources.

The potential for stormwater discharges to adversely affect Maori cultural values reinforces the need for RCAs to undertake early and adequate consultation with iwi before initiating a significant roading project (see Section 4.7 of these Guidelines).

6. Engineering Methods for Stormwater Management

6.1 Introduction

The uncontrolled run-off of stormwater from roads can lead to a variety of environmental problems including flooding, erosion, road instability, and adverse ecological effects in receiving waters. The engineering response to stormwater management issues is critical because it affects project costs, and an inappropriate choice of design solutions or “treatment” methods can lead to sub-optimal environmental outcomes.

The appropriate response to a stormwater management issue will depend on the local circumstances: the geology and soil type, rainfall, the amount of stormwater, population (traffic density) projections, existing and likely future contaminant loads, the sensitivity of receiving environments.

The approach to stormwater management should integrate the control of stormwater peak flows and pollutant removal/prevention with the aims of minimising downstream negative effects and mitigating road instability and erosion problems.

This Chapter 6 of the Guidelines deals with the design of pipes and channels, reduction of peak flows and run-off volumes, selection of the appropriate treatment methods for improving stormwater quality and preventing erosion and road instability problems. It also identifies methods that can be used to reduce the impacts of land-disturbing activities during the construction phase of a roading project.

This Chapter is not intended to be a “design manual”. Instead, it should be considered a “road map” to point the designer in the right direction in terms of options for designing stormwater management systems, guidance on maintenance requirements, and life-cycle cost considerations. It gives a relatively brief explanation of each issue or technique. Relevant references are provided, and these should be consulted if further information is required.

6.2 Route Selection

Route selection is fundamental to the design of new roads and to the improvements of existing roads. Many factors need to be taken into account at the initial route selection stage and at the concept design stage.

It cannot be overemphasised that fitting the function (roadway) to landscape form is of critical importance at the concept design stage. Apart from affecting the aesthetics of the new route, careful consideration of the stormwater management issues at an early stage in the project can save much time, money and frustration through all the project development phases: preliminary design, consent processes, detailed design, construction activities and ongoing maintenance.

At the route selection and concept design stage of a new road project or a roading improvement project, the following stormwater design and stormwater questions need to be addressed:

- How does the road fit the natural landscape?
- What is the nature of the existing natural drainage patterns?
- Is the downstream drainage system currently adequate?
- How best to deal with the run-off from the land adjacent to the road?
- What is the future land use adjacent to the road above and below likely to be?
- What are the consent issues likely to be during construction and after construction?
- How are the surface and subsurface flows within the road corridor best managed?
- What is likely to be the best method/technique of passing the natural drainage through the road corridor?

Selection of a route is not normally based on stormwater management concerns. The primary drivers for new routes or improvements will usually be other higher priority considerations such as safety, costs, benefits, and ease of construction. Nevertheless, consideration of stormwater management issues during route selection can help to avoid design problems and adverse environmental effects during and after construction.

Specific issues which need to be considered during concept design and route selection process are set out in Table 6.1.

Classification and characterisation of environmental impacts associated with different road classes are shown in Table 6.2.

A range of potential mitigation measures to reduce the ecological and environmental impact of road drainage are identified in Table 6.3 (and refer also to Chapter 5 of these Guidelines).

Recent research has indicated that run-off from road surfaces generates significant pollutant loads on receiving waters, and correlations have been made between pollutants generated and road traffic volumes (see Section 5.3.4). Increasing interest in the ecological effects of road run-off means close attention needs to be given to mitigation of such effects as an integral part of the road design process.

Budgetary allowances for treatment and disposal of run-off from the New Zealand roading network need to reflect the environmental setting of roads and road traffic volumes. Asset management plans should contain specific monitoring and maintenance programmes and budgets for each treatment system.

Table 6.1: Issues to be considered during route selection

Issue	Consideration	Examples (questions to ask)	Information Sources
Climate	Type of stormwater?	Snow? Ice? Rainfall?	Climate maps
	Intensity?	High? Moderate? Low?	Regional Rainfall Map
	Frequency?	High? Moderate? Low?	Regional Rainfall Map
	Volumes?	Large, requiring storage? Moderate? Small?	Analysis
Catchment	Steep, unvegetated slopes	Will rainfall, snow or ice cause soil or rock movement? (Particularly severe examples might be avalanche country or scree slopes)	Topographical maps; soils and geological maps; site inspection; historical information
	Steep vegetated slopes	Could vegetation be removed (e.g. by forestry operations or land clearing for agriculture)? Will instability occur if / when vegetation is removed? Will substantially larger volumes or rates of run-off occur when vegetation is removed?	Topographical maps; soils and geological maps; site inspection; historical information
	Flat ground	Can the water be readily moved away? Does the road need to be built up or does the drain need to be cut down to avoid flooding? If the area is peat, will drainage cause settlement?	Topographical maps; soils and geological maps; site inspection; historical information
Receiving Environment	Steep unvegetated slopes	Could the concentration of flows cause erosion?	Topographical maps; soils and geological maps; site inspection; historical information
	Steep vegetated slopes	Could the concentration of flows cause erosion?	Topographical maps; soils and geological maps; site inspection; historical information
	Flat ground	Can the water be readily moved away?	Topographical maps; soils and geological maps; site inspection; historical information

Table 6.1: Issues to be considered during route selection *(continued)*

Issue	Consideration	Examples (questions to ask)	Information Sources
Receiving Environment <i>(continued)</i>	Stream or river	What affect could the run-off have on natural water quality; the existing plant life or the existing wildlife? Does the water get used by humans and what affect could run-off have on that use?	Topographical maps; soils and geological maps; vegetation and wildlife profiles; land use maps; regional and district plans; site inspection; historical information
	Ponds, lakes or wetlands	How will the pond or lake modify the flow? What affect could the run-off have on the water levels, natural water quality; the existing plant life or the existing wildlife? Does the water get used by humans and what affect could run-off have on that use?	Topographical maps; soils and geological maps; vegetation and wildlife profiles; land use maps; regional and district plans; site inspection; historical information
	Estuary	What affect could the run-off have on natural water quality; the existing plant life or the existing wildlife? Does the water get used by humans and what affect could run-off have on that use?	Topographical maps; soils and geological maps; vegetation and wildlife profiles; land use maps; regional and district plans; site inspection; historical information
	Coastal	What affect could the run-off have on natural water quality; the existing plant life or the existing wildlife? Does the water get used by humans and what affect could run-off have on that use?	Topographical maps; soils and geological maps; vegetation and wildlife profiles; land use maps; regional, district and coastal plans; site inspection; historical information

Table 6.2: Road drainage-related impacts according to road class: potential construction or on-going impacts.

Drainage-related Environmental Issue or Impact	Urban Environment		Rural Environment		Natural Environment	
	Motorway	Highway or Main Road	Local Road (Sealed)	Motorway	Highway or Main/Local Road	Unsealed Local Road
1. Hydrological Disturbances <i>Disruption in surface and subsurface flows due to:</i> <ul style="list-style-type: none"> - Changes in flows and peak discharge - Changes in catchment surface hydrology - Changes in recharge/discharge of groundwaters 	High			High High	High High	
2. Water Quality Disturbances <i>Deterioration in quality of receiving waters due to:</i> <ul style="list-style-type: none"> - Increased sediment (turbidity/suspended solids) - Increased nutrients - Increased heavy metals and organic compounds 	High	High			High	High
3. Ecological Disturbances <ul style="list-style-type: none"> - arising from hydrological and water quality changes and direct habitat disturbance <i>Changes in habitat structure and diversity due to:</i> <ul style="list-style-type: none"> - Roadside and riparian vegetation removal & decline - Pollution or habitat destruction of aquatic species - Disruptions to corridor values - Transport of weed seeds and disease 	High High	High		High High	High High High	High High High

Source: Water sensitive road design: design options for improving stormwater quality for road run-off. ARRB Technical Report 00/1, August 2000, ARRB Austroads.

Table 6.3: Mitigation measures to reduce the ecological and environmental impacts of road drainage (see also Chapter 5).

Road Development phase	Zone or Environmental Setting		
	Urban environment	Rural environment	Natural environment
Planning	<ul style="list-style-type: none"> Consider alternative transportation options Ensure sufficient space to install water quality treatment structures 	<ul style="list-style-type: none"> Select corridor and alignment to avoid disruption of flows into or away from sensitive areas 	<ul style="list-style-type: none"> Select corridor and alignment to avoid disruption of flows into or away from sensitive areas Seek to control secondary developments arising from introducing the road
Design	<ul style="list-style-type: none"> Characterise and assess urban catchment hydrology impacts Design performance of water treatment structures according to water quality targets Undertake risk analysis to ensure design of spill containment structures meets environmental and cost objectives 	<ul style="list-style-type: none"> Characterise rural catchment hydrology impacts Design hydraulic structures to perform well and avoid scour Ensure sound table-drain design Design for treatment of bridge deck drainage before discharge to natural waterways 	<ul style="list-style-type: none"> Characterise rural catchment hydrology impacts Design hydraulic structures to perform well and avoid scour Ensure sound table-drain design Design for treatment of bridge deck drainage before discharge to natural waterways
Construction	<ul style="list-style-type: none"> Minimise erosion and sedimentation through best management practices on-site 	<ul style="list-style-type: none"> Enforce procedures to minimise disturbance of remnant vegetation Minimise erosion and sedimentation through best management practices on-site 	<ul style="list-style-type: none"> Enforce procedures to minimise disturbance of natural areas Minimise erosion and sedimentation through best management practices on-site
Operation	<ul style="list-style-type: none"> Ensure correct operation and maintenance of water quality management structures 	<ul style="list-style-type: none"> Implement sound table-drain (and other hydraulic structures) maintenance practices 	<ul style="list-style-type: none"> Manage table-drain (and other hydraulic structures) maintenance practices to protect sensitive roadside communities (both terrestrial and aquatic)

Source: Water sensitive road design: design options for improving stormwater quality of road run-off
ARRB Technical Report 00/1, August 2000, ARRB Austroads.

6.3 Assessment of Level of Service

“Level of service” is the standard to which the drainage system must perform. It is typically expressed as a probability or risk of occurrence, using the term Annual Exceedance Probability (AEP) or the term Average Recurrence Interval (ARI). The definitions of these terms are:

Annual Exceedance Probability (AEP) – is the probability of exceedance of a given discharge within a period of one year.

Average Recurrence Interval (ARI) – the expected average time (in years) between exceedances of a given discharge.

Comment

The word “average” is a key part of the definition of recurrence interval. Hydrological events are generally random occurrences, so it must not be inferred that a flood of a particular ARI will be exceeded at regular intervals. It is important that this is made clear to clients, decision-makers and potentially affected parties.

ARI and AEP have the following relationship:

$$AEP = 1(\text{year})/ARI(\text{years}) \times 100 (\%)$$

So, the probability that the 100-year ARI peak flow will be equalled or exceeded in any one year is 0.01 or 1%.

Transit New Zealand uses the *State Highway Control Manual*⁵⁸ to state procedures and provide guidance for any person or organisation that has dealings with state highways.

The level of service that applies to stormwater from roads is set by the Road Controlling Authority (RCA). Transit New Zealand is the RCA for all state highways. Table 6.4 defines Transit’s levels of service for stormwater.

Table 6.4: Levels of service for State Highways.⁵⁹

<ul style="list-style-type: none"> • For a culvert, the design shall (except as set out below) allow for the passage of the 10-year return period (ARI) flood without heading up. The design shall allow for the passage of the 100-year return period (ARI) flood by heading up to a maximum level 0.5 m below the road surface. If the heading-up condition is considered, the design shall ensure embankment stability under flood conditions, and adequate protection to safeguard against piping, and against scour due to increased water velocity. • For a culvert on a route carrying less than 750 vpd, less stringent criteria will be allowed. The design shall allow for passage of the 10-year return period (ARI) flood by heading up to a maximum level 0.5m below the road surface; and for passage of the 100-year return period (ARI) flood by overtopping the embankment to a maximum depth of 0.2 m. The design shall also ensure: <ul style="list-style-type: none"> – Generous sight distance to the flooded roadway; – Stability of the embankment under flood conditions; – Scour protection, particularly of the downstream shoulder and embankment slope; – Adequate protection to safeguard against piping.

⁵⁸ Transit New Zealand (latest version). *State Highway Control Manual*. State Highway Management Division. *Comment: The Control Manual is a dynamic document, so it should be checked for updates.*

⁵⁹ Transit NZ. 1994. *Bridge Manual: design and evaluation*.

Table 6.5 provides an example of clearly stated levels of service by a territorial local authority (TLA):

Table 6.5: Levels of service for Local Authority roads.

<p>Flooded once every 2 years: <i>Minor urban roads with alternative routes for access, parks and reserves, secondary overland flow paths through publicly controlled land or drainage easements.</i></p>
<p>Flooded once every 5 years: <i>Minor urban roads without alternative access (e.g. culs-de-sac), most urban roads, important recreational fields, backyards of property, secondary overland flow paths through private property where nuisance and damage will be minimal.</i></p>
<p>Flooded once every 20 years: <i>Primary roads, detention structures designed to withstand damage and failure from being overtopped, non-habitable residential buildings such as storage sheds, basements and garages.</i></p>
<p>Flooded once every 50 years: <i>Floors of habitable dwellings, floors and basements of commercial and industrial buildings.</i></p>
<p>Flooded once every 100 years: <i>Arterial roads.</i></p>
<p>Flooded once every 200 years: <i>Flood detention structures not specifically designed to withstand being overtopped, major community facilities related to supply of electricity, telephone, water and sewage disposal.</i></p>
<p>Where the consequences of the design flow being exceeded are severe (e.g. total inundation of buildings), then the ARI shall be higher than specified above.</p>

Source: Wellington City Council. 1994. *Code of Practice for Land Development*.

The *NZ Building Code Handbook, Approved Document E1*, sets levels of services for prevention of property and home inundation. NZS 4404:2004 sets levels of service for subdivision design (see Section 3.3.4 of these Guidelines). These may be adopted where the TLA does not have a specific code of practice.

6.4 Hydrological Assessment

6.4.1 Estimation of Design Flood (Peak Flow Rate)

6.4.1.1 Objectives

This section briefly outlines the methods available for estimating the peak flow rate during the design flood.

6.4.1.2 Methods

Several methods are available for estimating flows from rural and/or urban catchments. For roads, the Rational Method is commonly used because the typical road catchment is relatively small and is also relatively simple.

Comment

Over the years a number of methods have been used in New Zealand for the estimation of run-off to streams in rural and/or urban catchments. Table 6.6 gives a brief description of some more common methods and their application.

Table 6.6: Methods for estimating run-off to streams.

Method	Brief Description	Application
<i>For Gauged Catchments</i>		
Flood Frequency Analysis	for catchments with long streamflow records	Rural catchments
Unit Hydrograph	for catchments with limited streamflow records	Rural catchments Urban catchments
Run-off Routing	for catchments with limited streamflow records	Rural catchments Urban catchments
<i>For Ungauged Catchments</i>		
Computer Models	specialised models, developed and calibrated for specific catchments	Rural catchments Urban catchments
Regional Methods	for ungauged catchments, using flood frequency methods	Rural catchments
Rational Method	for ungauged catchments; a probabilistic method relating run-off directly to rainfall	Rural catchments Urban catchments
Run-off Routing	for catchments with limited streamflow records	Rural catchments Urban catchments

Source: Austroads. 1994. *Waterway Design: A Guide to the Hydraulic Design of Bridges, Culverts and Floodways*.⁷³

6.4.1.3 The Rational Method

The Rational Method⁶⁰ is a relatively simple method that is widely used and well documented. The formula is a simple mathematical representation of the proportion of rainfall that produces direct run-off, which flows in the man-made systems of pipes, detention basins, open channels, or in natural streams or rivers. The Rational Formula calculates only the peak flow resulting from what is termed the critical storm for the catchment area under consideration. The duration of the critical storm is assumed to be equal to the time of concentration for the catchment.

The Rational Formula is: $Q = CIA/360$

- where:
- Q = run-off (m³/s)
 - C = run-off coefficient
 - I = rainfall intensity (mm/h)
 - A = catchment area (ha)

Run-off Coefficient, C

The run-off coefficient C is used to represent the catchment response to rainfall. It is a simple constant that necessarily over-simplifies many complex and inter-related factors. Such factors are soil type, vegetation cover, surface impermeability,

⁶⁰ NZ Institution of Engineers. 1980. *A Guideline and Procedure for Hydrological Design of Urban Stormwater Systems*.

topography, natural catchment storage, soil moisture, storm intensity, storm duration, storm direction, catchment shape, time of concentration.

There are many documents that list run-off coefficients. The following Tables 6.7, and 6.8 show coefficients for both urban and rural areas respectively.

Table 6.7: Run-off Coefficient (C) for urban areas.

Description of Surface	C
Impermeable surfaces (such as roofs)	0.90
Asphalt and concrete paved surfaces	0.85
Yard paving panels with sealed joints	0.80
Bare impermeable clay with no interception channels or run-off control	0.70
Industrial, commercial, shopping areas and townhouse developments	0.65
Bare soil of medium soakage	0.60
Yard paving panels with open joints	0.60
Residential areas in which impervious area is 36% to 50% of gross area	0.55
Unsealed roads	0.50
Residential areas in which the impervious area is less than 36% of gross area	0.45
Railway, unsealed yards and similar surfaces	0.35

Source: NZ Building Industry Authority. 1992. *New Zealand Building Code Handbook, Approved Document E1: Surface Water, Table 1.*

Table 6.8: Run-off Coefficient (C) for rural areas.

Description of Surface	C
Bare impermeable clay with no interception channels or run-off control	0.7
Bare uncultivated soil of medium soakage	0.6
<i>Heavy clay soil types:</i>	
Pasture and grass cover	0.4
Bush and scrub cover	0.35
Cultivated	0.3
<i>Medium soakage soil types:</i>	
Pasture and grass cover	0.3
Bush and scrub cover	0.25
Cultivated	0.2
<i>High soakage gravel, sandy and volcanic soil types</i>	
Pasture and grass cover	0.2
Bush and scrub cover	0.15
Cultivated	0.1

Source: NZ Institution of Engineers. 1980. *A Guideline and Procedure for Hydrological Design of Urban Stormwater Systems (Section 4.3.2)*⁶⁰

Comment

It is important when using this seemingly simple method that the designer adjusts the value of C to take account of more complex situations. These might include more than one land use or more than one surface type.⁵⁵ It should also be noted that C varies dependent on the antecedent conditions, i.e. the run-off coefficient will be higher for saturated soil than for dry soil. The run-off coefficient will also vary with storm intensity. NZIE (1980)⁶⁰ gives further guidance on the selection of an appropriate run-off coefficient.

Rainfall Intensity, I

The rainfall intensity I is defined as the average intensity of rainfall for the design storm. The design storm will have:

- a duration equal to the Time of Concentration T_c (see below);
- an ARI appropriate to the level of service.

Comment

NIWA,⁶¹ all Regional Councils and many TLAs maintain up-to-date rainfall records. A request should be made to the hydrology department of the nearest organisation(s), to obtain the locations of rainfall measuring sites and the type and length of records available at those sites. Once a copy has been obtained, the rainfall records can be used to determine the intensity at the site for the appropriate duration and ARI. If “raw” rainfall data requires analysis, then any one of many standard texts (such as Ven Te Chow⁶²) can be followed to carry out depth / duration / frequency analysis.

NIWA has produced software, called HIRDS, that can produce a table of rainfall depth–duration–frequency for any location in New Zealand. The software simply interpolates rainfall contours that were produced using data from long-term rainfall sites around New Zealand. The limitation is that the data was collected between 1960 and 1980 and has never been updated. Thus, while it is very convenient, HIRDS should be used with caution.

Time of Concentration, T_c

The time to be used in selecting a rainfall intensity is the “time of concentration”, or the time taken for water to travel from the farthest part (in time) of the catchment to the outlet.

For *urban catchments*, the time of concentration includes the time of overland flow and the time of flow in drains (gutters, pipes and open drains) up to the point under consideration. The time of concentration (T_c) (in minutes) is calculated as follows:

$$T_c = T_e + T_f$$

- where: T_e = time of entry, including time of overland flow, time of gutter flow and entry into the drainage system
 T_f = time of flow in piped system

For *rural catchments*, several methods can be used for calculating time of concentration. These include:

Ramser-Kirpich equation:

$$T_c = 0.0195 L^{0.77} S_a^{-0.385}$$

⁶¹ NIWA National Institute of Water and Atmospheric Research Limited.

⁶² Ven Te Chow. 1964. *Handbook of Applied Hydrology*. McGraw-Hill, New York.

where: T_c = time of concentration (minutes)
 S_a = average channel slope (m/m)
 L = flow length from the farthest point on the catchment to the point under consideration (m)

Bransby-Williams equation:

$$T_c = 0.953 L^{1.2} / A^{0.1} H^{0.2}$$

where: T_c = time of concentration (hours)
 L = maximum flow length (km)
 A = catchment area (km²)
 H = difference in elevation between highest and lowest points on the main channel (m)

US Soil Conservation Service:

$$T_c = (0.87 L^3 / H)^{0.385}$$

where: T_c = time of concentration (hours)
 L = maximum flow length (km)
 H = difference in elevation between highest and lowest points on the main channel (m)

The chosen time of concentration should not be arrived at by simply averaging the results of the above formulae. It should be the value considered the most reasonable for the catchment and for the design storm. A useful check on the chosen value is to convert it to an average flow velocity and then to decide, by comparison with stream velocities, whether it is realistic.⁶³ Only a realistic value should be used.

Area, A

The catchment area may be determined using contour plans and confirmed by physical inspection of the site.

6.4.2 Effect of Climate Change

When designing stormwater systems, the effects of future climate change should be considered.

Atmospheric concentrations of greenhouse gases are increasing, due largely to human activities. Continued future growth in greenhouse gas emissions is predicted to lead to significant increases in the average surface temperature of the planet.⁶⁴

Quantitative projections of the impacts of climate change over a region such as New Zealand are difficult. This is because of the uncertainties in regional climate change projections, the limited knowledge about sensitivities of some systems (both natural

⁶³ Ministry of Works & Development. 1980. A method for estimating design peak discharge. *MWD Technical Memorandum No. 61*.

⁶⁴ Intergovernmental Panel on Climate Change. 2001. *Climate Change 2001: The Scientific Basis*. (<http://www.ipcc.ch/pub/tar/wg1/011.htm>)

ecosystems and managed agricultural activities) to climate, and the interactions of multiple climatic and non-climatic factors on such systems.⁶⁵

Detailed evaluation of climate records by NIWA scientists has shown that since 1977:⁶⁶

- The north and east of the North Island has become 10% drier and 5% sunnier with more droughts;
- The west and south of the South Island has become 10% wetter and 5% cloudier with more damaging floods;
- Fewer frosts are occurring nationwide;
- The retreat of the West Coast glaciers has halted but eastern glaciers continue to shrink;
- Night temperatures continue to rise.

The changes in average temperature and rainfall totals have impacted on the number of climate extremes, such as frosts, floods and droughts.⁶⁶

Model simulations suggest changes of as much as $\pm 20\%$ in soil moisture and run-off in Australia by 2030, with considerable variation from place to place and season to season and with the possibility of an overall reduction in average run-off. A preliminary study for an urban area near Sydney showed a tenfold increase in the potential damage of the “100-year” flood under a doubled CO₂ scenario.⁶⁵

When designing stormwater systems it is important to use up-to-date hydrological data, since data that is 50 years old may not be relevant for designing stormwater systems for the future. Consideration should also be given to the likely continuing trends in climate change.

6.4.3 Stormwater Volumes

6.4.3.1 Objectives

Volume of run-off should be determined when storage is proposed or where ponding may affect the rate of run-off. Examples include where:

- Storage (a pond, lake or dam) is available in the drainage system;
- Pumping is required and the pump well has a significant volume that will alter peak flows;
- Flood waters can “escape” in one or more locations along the drainage system.

6.4.3.2 Methods

Stormwater volumes can be determined using either measured information or synthetic information, as described in Table 6.9.

⁶⁵ NIWA, Regional Impacts of Climate Change (<http://katipo.niwa.cri.nz/ClimateFuture/impacts.htm>)

⁶⁶ NIWA 1998, Significant shift in New Zealand climate – Media release (6 August 1998)

Table 6.9: Determining stormwater volume.

Method	Description	Application
Hydrograph Measurement	Measurement of stage and / or flow for a variety of events. May also require concurrent measurement of local rainfall.	To allow “scaling up” to match the design level of service will preferably involve correlation of the measured flow or rainfall with a longer record. If this is not possible or the record is not long enough, peak flows may be scaled by comparison with the Rational Method.
SCS Synthetic Hydrograph	A “typical” unit hydrograph developed by the Soil Conservation Service from a large database of measured hydrographs from a wide range of situations.	Easily used when there is no measured hydrograph. Suitable for use with the Rational Method since it only requires knowledge of time of concentration and peak flow.

Synthetic Hydrograph Method

This method, developed by the US Soil Conservation Service (SCS)⁶⁷ for constructing synthetic unit hydrographs, is based on a dimensionless hydrograph. This dimensionless graph is the result of an analysis of a large number of natural unit hydrographs from a wide range in size and geographic locations (Figure 6.1).

The method requires only the determination of the time to peak and the peak discharge. It can therefore be used conveniently with the Rational Method of determining peak flow rate, described in Section 6.4.1.3 of this report.

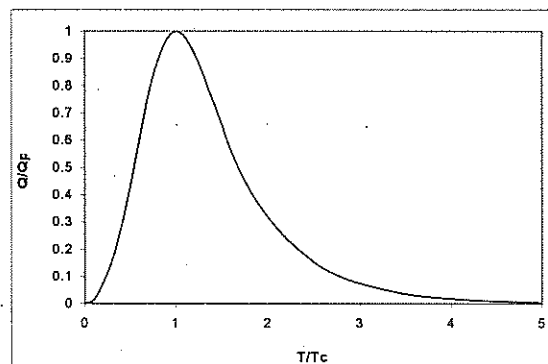


Figure 6.1: SCS Synthetic Unit Hydrograph. Source: from US SCS⁶⁷

Q/Q_p = Ratio of flow (Q) to peak flow (Q_p)
 T/T_c = Ratio of time of Q (T) to time of concentration (T_c)

⁶⁷ Viessman, W., Lewis, G.L. 1996. *Introduction to Hydrology*. 4th edition, Addison-Wesley, Boston.

6.5 Road Surface Design

6.5.1 Introduction

For safety reasons it is important that rainfall is drained from the road surface quickly. Excess water on the surface of the road can cause vehicles to aquaplane and lose control.

6.5.2 Objective

The critical depth for aquaplaning ranges from 4mm to 10mm depending on tyre and pavement surface.⁶⁸ The surface water depth should therefore be restricted to 4 mm.

6.5.3 Design Guide

Most local authorities define an acceptable range of slope (longitudinal and crossfall), which generally will have been derived from the MWD 1977 Design Guide.⁶⁸

A crossfall lower limit of 2.5% is typically set to minimise ponding in surface deformations. Increasing pavement crossfall does not have a marked effect on reducing flow depth, so crossfall is not typically adjusted for reasons of stormwater management.⁶⁸

6.5.4 Determining Water Depth on the Road Surface

Surface water depth depends on the slope of the road surface and on whether the road surface is permeable or impermeable.

6.5.4.1 Impermeable Road Surface

Assuming zero infiltration through the road surface, surface water depth (above the top of texture) can be calculated using the following formula:⁶⁸

$$D = 0.046 (L_f I)^{1/2} / S_f^{1/2}$$

where: D = depth of flow (mm) at the end of the flow path
 L_f = length of flow path (m)
 I = rainfall intensity (mm/h)
 S_f = flow path slope

The flow path slope is given by:

$$S_f = (S_l^2 + S_c^2)^{1/2}$$

where: S_l = longitudinal slope (grade)
 S_c = crossfall of road surface

Flow path length is given by:

$$L_f = W(S_f / S_c)$$

where: W = width of pavement contributing to flow

⁶⁸ Ministry of Works & Development. 1977. *Highway Surface Drainage: Design Guide for Highways with a Positive Collection System*.

6.5.4.2 Permeable Road Surface

Infiltration can reduce the water depth on the surface. The amount of infiltration will depend on the pavement type, and specific design is required for each pavement type. An example of a permeable surface is shown in Figure 6.2.

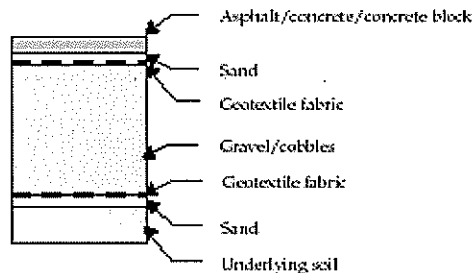


Figure 6.2: Cross-section of a permeable road surface.

6.6 Drainage Systems

6.6.1 Introduction

The amount of stormwater run-off that occurs in urban areas is often substantially greater than in rural areas because of the higher proportion of impervious surfaces in the catchment. In principle, the approach to design of pipes and channels is the same although the methods used and the resulting structures may be quite different.

6.6.2 Objective

The objective of drainage system design is to ensure that level of service is met in the most cost-effective manner.

6.6.3 Procedure

Table 6.10: Steps in drainage system design.

Step	Reason	Method
Decide on level of service		See Section 6.3
Calculate peak flow rate	Drains are normally sized to take the peak flow rate.	See Section 6.4.1
If necessary, calculate volume of run-off	Volume of run-off is required when storage is proposed or where flooding can be expected to occur.	See Section 6.4.3
Design storage (if used)	Storage, if used, can reduce the peak / design flow in the drain.	For storage design, see Section 6.6.4
Determine drain size		For pipeline, see Section 6.6.5 For culvert, see Section 6.6.6 For open drain, see Section 6.6.7

Note: Secondary flow paths need to be taken into account when designing a drainage system. The secondary flow path is the path that stormwater takes when the drain is full or inoperable due to blockage, etc.⁶⁹ When designing stormwater drainage systems, the secondary flow path should be identified to ensure that property will not be damaged or safety problems caused during the operation of the secondary flow path.

6.6.4 Storage Design

6.6.4.1 Introduction

Ponds tend to be introduced to a drainage system for two different functions: for flood detention and/or stormwater treatment. Ponds designed for treatment are discussed in Section 6.8. Ponds designed for flood detention are discussed here.

6.6.4.2 Extended Detention (ED) Ponds

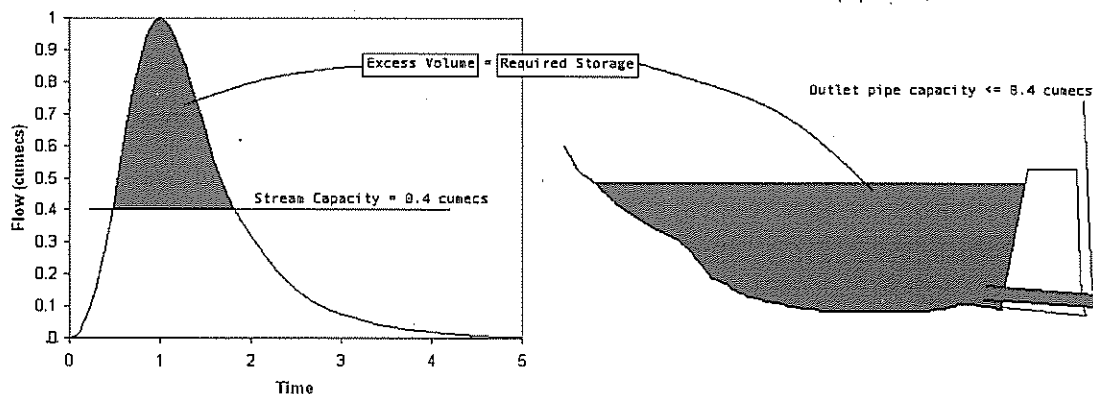
Extended detention (ED) ponds fill during a storm and empty slowly between storms. Typically the ED pond is associated with an open area such as a park or sports field. While the drain may be open or piped, it is more common to be associated with an open drain. At the downstream end of the drain there will be some sort of controlled outlet that limits the rate of outflow from the area. This may take the form of a weir, a gate or a pipe with limited capacity. The controlled outlet forces excess water to be detained in the open area during the storm and ensures controlled release until the pond is emptied.

Sizing the pond involves ensuring that the volume of storage available at the start of the design storm is equal to, or greater than, the excess stormwater volume.

Comment

A simple volume balance is often sufficient, and an example is given here. Where space is limited or the volumes are large and will be modified during passage of the flood, more elaborate methods such as flood routing may be appropriate. Standard texts (such as Ven Te Chow⁶²) may be consulted or a computer program used.

Example of a simple volume balance:



⁶⁹ Wellington City Council. 1994. *Code of Practice for Land Development*.

6.6.4.3 Wet Ponds

Wet ponds, as their name suggests, remain permanently full. These ponds are generally vegetated around the fringes and may include islands and wetland vegetation.

The advantage of a wet pond is that it combines flow modification with the treatment that can occur in the permanent pool. Wet ponds also provide habitat, wildlife linkages and visual amenity.

Design and operation for flood detention is described more fully in the previous Section 6.6.4.2. More detailed information is available in the ARC's TP10.⁷⁰

6.6.4.4 Combined Wet – Extended Detention Ponds

Combined Wet and ED ponds are something between a wet pond and an extended detention pond. Part of the pond is maintained as a permanent pool. The volume above the permanent pool fills during a storm and slowly empties.

Combined ponds share some of the advantages and disadvantages of wet and extended detention ponds. Small storms are captured and treated in the permanent pool. Some attenuation of small storm flows will be provided. There is also some biological uptake in the permanent pool. Water level changes are not as large as with an extended detention pond, so wetland plants are easier to grow and a more diverse range of plants will probably be established compared with a wet pond.

More detailed information is available in the ARC's TP10.⁷⁰

6.6.5 Pipeline Design

6.6.5.1 Methods

A number of different methods are used to determine the required pipe size and type including:

- Tables / Graphs / Flow Nomographs
- Manning's Equation
- Darcy-Weisbach Equation
- Colebrook-White Equation
- Hazen-Williams Equation
- Computer Analysis (usually based on one of the above)

Two common methods of pipeline design are Tables / Graphs / Nomographs and Manning's Equation. These two approaches are briefly discussed here, but refer also to section 4.3.12.3 of NZS 4404:2004.⁷¹

⁷⁰ Auckland Regional Council. 2002. Stormwater Treatment Devices – Design Guideline Manual. ARC Technical Publication No. 10 (revision of 1992 draft).

⁷¹ SNZ. 2004. Land Development and Subdivision Engineering. NZS 4404:2004.

Comment

References to other methods are contained in hydraulic textbooks and suppliers' literature. The relationship between the Manning's, Darcy-Weisbach, Colebrook-White and Hazen-Williams equations is briefly summarised in the CPAA Hydraulic Design Manual.⁷²

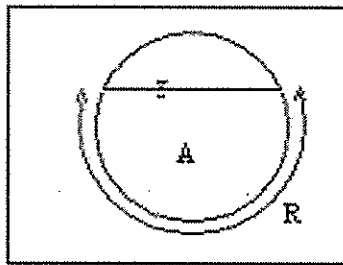
6.6.5.2 Tables / Graphs / Nomographs

Experiments at Wallingford, England, on a wide range of pipe sizes and materials led to the production of widely used tables in the UK DoE⁷³ Hydraulics Research Paper No. 4, based on the Colebrook-White Equation.

Charts and nomographs are also readily available, either in hydraulic textbooks or in suppliers' literature.

6.6.5.3 Manning's Equation

Manning's Equation is relatively simple, and is often used in the design of stormwater pipes.



Manning's Equation: $Q = AR^{2/3}S^{1/2}/n$

- where:
- Q = flow rate (m³/s)
 - A = cross sectional area of flow (m²)
 - R = hydraulic radius = A / P (m)
 - P = wetted perimeter (m)
 - S = slope (m/m)
 - n = roughness coefficient

For a circular pipe flowing full, Manning's Equation can be readily expressed in terms of the pipe diameter, D:

Manning's Equation for a full-flowing pipe: $Q = 0.312D^{7/3}S^{1/2}/n$

Comment

An implicit assumption is that the slope of the pipeline is the same as the slope of the water surface. This means that the energy loss along the pipeline is related only to the roughness (n) of the pipe.

Roughness coefficient, n

Pipe type will influence the roughness coefficient 'n'.

⁷² Concrete Pipe Association of Australasia (CPAA). 1997. *Hydraulics of Pre-cast Concrete Conduits, Pipes and Box Culverts, Hydraulic Design Manual*. New Zealand edition.

⁷³ UK Department of the Environment. 1977. Tables for the Hydraulic Design of Pipes, Metric edition. *Hydraulics Research Paper No. 4*.

The pipe type that is most suitable for a particular location depends on a number of factors including soil type, depth below ground, laying conditions, expected life, availability and cost.

The results of site inspections and soils investigations can be used to define the soil type in the area that the pipe will be laid. While most pipe materials are suitable in typical soils, it is wise to check. For example, in soft and wet soils, chemicals in either the soil or the groundwater may make a galvanised steel pipe unsuitable. If a lot of gravel movement occurs then abrasion resistant pipe materials may be required.

Soil type, depth below ground and laying conditions will affect the structural demands on the pipe. The NZ Building Code⁷⁴ requires all drains to be constructed to withstand the combination and frequency of loads likely to be placed upon them without collapse, undue damage, undue deflection or undue vibration. This is not only a material selection issue but also depends on support of the pipe, including the bedding and backfilling materials that will be used.

Material properties are given in literature from suppliers; the standards with which materials must comply are listed in the New Zealand Building Code⁷⁵ or are available from the NZ Standards Association.

Specific values of the roughness coefficient 'n' can be obtained from suppliers' literature. Typical values for stormwater flow in pipes are given in Table 6.11.

Table 6.11: Manning's Roughness Coefficient, n, for pipes of different diameters.

k (mm)	Pipe Diameter (mm)			
	300	1200	2100	3000
0.15	0.010	0.011	0.011	0.012
0.6	0.011	0.012	0.0125	0.013
1.5	0.013	0.013	0.0135	0.014

where k = Colebrook-White roughness coefficient

Table applies to velocity range: $v = 0.5$ to 8 m/s

Part Full Flow

Stormwater pipelines may be designed to run either full or part full under design conditions. The Manning's Equation is normally used to design for full pipe flow. Should part full flow occur, the performance of the pipe is most easily analysed using the following graph (Figure 6.3, on p.120).

6.6.6 Culvert Design

Culverts may be regarded as short pipelines in which significant energy loss occurs at the inlet and outlet as well as along the pipe itself.

⁷⁴ NZ Building Industry Authority, *New Zealand Building Code Handbook*, Approved Document B1.

⁷⁵ NZ Building Industry Authority, *New Zealand Building Code Handbook*, Approved Document E1: Surface Water, Section 3.1.

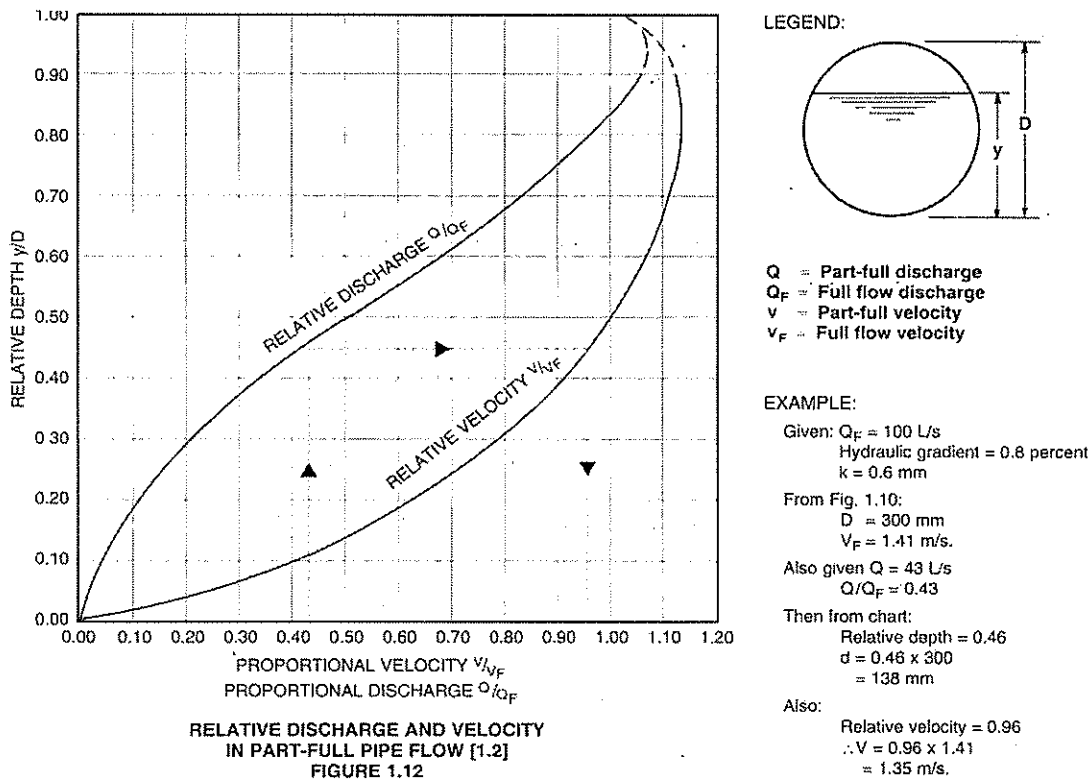


Figure 6.3: Relative discharge and velocity in part-full pipe flow. Source CPAA 1997⁷²

While it is possible to carry out culvert design by looking at the pipe, inlet and outlet separately, the most common method is to use nomographs. Austroads⁷⁶ has a fully detailed method of culvert design using nomographs.

The capacity of a particular culvert is governed by one of three conditions: inlet control, outlet control, and pipe capacity. When designing a culvert, the capacity of the pipe under all three conditions should be calculated, and the lowest value taken as the capacity. The condition governing the capacity of the pipe depends on:

- Headwater depth
- Tailwater depth
- Culvert diameter
- Inlet / Outlet configuration
- Culvert length
- Slope
- Roughness

⁷⁶ Austroads. 1994. *Waterway Design: a guide to the hydraulic design of bridges, culverts and floodways*. Austroads, Haymarket, NSW.

6.6.7 Open Drain Design

Flow in open channels has been nature's way of conveying water on the surface of the earth through rivers and streams.⁶² Man-made open channels are also a useful way of conveying stormwater.

The two most common equations for uniform flow in open channels are the Chezy and the Manning's Equations.⁷⁷ Flow in an open channel is generally considered to be uniform if the depth of flow is approximately constant in the direction of flow.

Manning's Equation can be used in the same way as it is for pipelines, as follows, with a few small differences explained below:

$$Q = AR^{2/3}S^{1/2}/n$$

where: Q = flow rate (m³/s)
 A = cross sectional area of flow (m²)
 R = hydraulic radius = A / P (m)
 P = wetted perimeter (m)
 S = slope (m/m)
 n = roughness coefficient

However the cross sectional area (A) and wetted perimeter (P) will be calculated differently than for pipes. Also the roughness coefficient will generally be different in an open channel than in a pipe (Table 6.12).

Table 6.12: Manning's Roughness coefficients (n), relevant to open channels

Source: Vennard & Street⁷⁷

	n
<i>Man-made channels</i>	
Steel	0.012
Timber	0.012
Concrete (troweled)	0.013
Concrete (gunite)	0.019-0.022
Good ashlar masonry or brickwork	0.015
Rubble masonry	0.025
Asphalt	0.013-0.016
Earth (clean)	0.022
Earth (with vegetation)	0.027-0.035
<i>Natural Channels</i>	
Clean and straight	0.030
Winding with some pools and shoals	0.040
Very weedy, deep pools	0.100
Mountain streams	0.040-0.050
Major streams (width greater than 30m at flood stage)	0.025-0.100

6.7 Surface and Subsoil Drainage Design

6.7.1 Introduction

It is important in roading and stormwater design to prevent erosion and road instability (from wet ground conditions). This can be achieved by managing both

⁷⁷ Vennard, J.K., Street, R.L. 1982. *Elementary Fluid Mechanics*. 6th edition. John Wiley & Sons.

surface and subsurface flows within the road corridor, as well as the passing of natural flood flows through the road corridor. Water control is the most important factor in highway design and construction.

Road pavements can be severely damaged by the presence of water. This section deals with drainage methods for preventing road instability. It is orientated towards design of drainage systems for rural roads, although some parts will also be applicable to urban roads too.

6.7.2 Surface Drainage

Surface drainage comprises those elements that collect and remove water from the surface of the road. It includes culverts and any other drainage system designed to intercept, collect and dispose of surface water flowing towards and onto road surface from adjacent areas.⁷⁸

6.7.2.1 Water Tables (Open drains)

Water tables run parallel to the road and drain water from the road surface and adjoining slopes. These drains are usually placed in cut sections, but can also be used along the toe of a fill section. Water tables can have a flat bottom and may be lined or unlined. In many rural situations it is likely that the water table will be unlined.⁷⁸

Water tables on the low side of a road run into side drains or turn-offs. Those on the high side of the road run into gullies, which are located at the culvert points.⁷⁸

The shape of a water-table drain will depend on the capacity required. For a low capacity drain, a V-shaped drain may be adequate. Where a higher capacity is required, a trapezoidal shape will be more suitable. The capacity of a water-table drain can be calculated using the method outlined in Section 6.6.7 of this Chapter.

The longitudinal slope of the drain must be adequate to avoid silting, and should be below a value at which scouring and erosion can occur. Bofinger et al. (1990)⁷⁹ recommend a minimum longitudinal slope to avoid silting of 0.5% (1:200) for an unlined ditch, and 0.33% (1:300) for a ditch lined with concrete or asphalt. Also they recommended a maximum slope of 5% (1:20) for an unlined ditch. Provisions to prevent erosion are recommended for ditches which, due to topography, cannot be restricted to less than 5% longitudinal slope.

Safety considerations must be made when designing a water table: for example Transit New Zealand has a guideline for maximum side slope to be 1 in 5.

⁷⁸ Australian Road Research Board Ltd (ARRB). May 1993. *Unsealed Roads Manual – Guidelines to Good Practice*. ARRB, Melbourne.

⁷⁹ Bofinger, H., Curtaene, P.C., Marais, C.P. et al. 1990. The design, construction and maintenance of low volume rural roads and bridges in developing areas. *CSIR Division of Roads and Transport Technology. Synopsis Report S89/2*. CSIR, Pretoria, South Africa.

6.7.2.2 Catch Drains⁷⁸

Catch drains are used to drain water flowing towards the road from the surrounding area. These drains are often used at the top of deep cuts. The same care should be taken, as for other surface drain types, to prevent erosion and scour. If the material surface is prone to scour and it is undesirable to cut the natural surface, catch drains can be formed by creating levees or catchbanks. Catch drains at the top of slopes are frequently located beyond the reach of equipment for maintenance. Thus, when designing catch drains, consideration should be given to access for maintenance purposes.

Vegetating the drain is an environmentally sound way to minimise erosion.

6.7.3 Subsoil Drainage

Although adequate surface drainage is the first step in providing good internal moisture control for the paved surface, a properly designed and installed subsoil drainage system is essential. Subsoil drainage is used to keep the ground-water table well beneath the paved surface.⁸⁰

Subsoil drains must be able to pass water without clogging over a long period. They should not be expected to transmit large flows of water, and should not be used or designed to drain surface water.

Subsoil drains can be divided into three main types:⁸⁰

1. *Standard Subsoil Drains*

Traditional standard subsoil drains are placed at least 1m below the finished subgrade level to maintain a lower ground-water table (Figure 6.4).

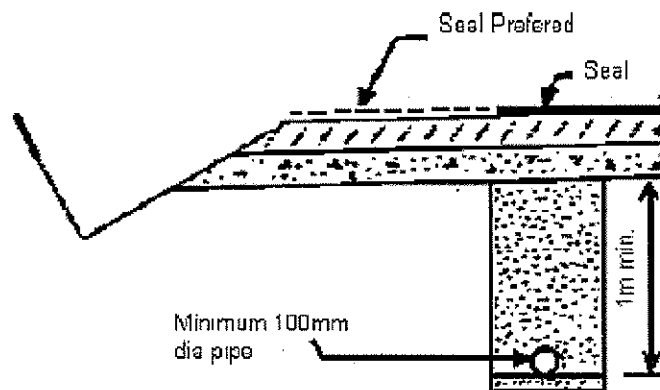


Figure 6.4: Standard longitudinal drain where the objective is to control ground-water table level. Source: Transit New Zealand⁸⁰

Deep drains are more effective than shallow drains in maintaining a low ground-water table. While this is as true in heavy clay soils as in the more permeable materials, the area of significantly lowered ground-water level for heavy clay soils is only in the immediate vicinity of the drain trench.

⁸⁰ Transit New Zealand, Specification TNZ F/2 Notes: 2000.

Although properly placed subsoil drains can maintain a lower ground-water table and control capillary rise, they will not completely eliminate the upward movement of moisture in all soils. On certain subgrades placing a sand or other granular sub-base course is essential in order to intercept and remove capillary moisture as fast as it accumulates.

Provision should normally be made for the section of the sub-base course that is located below the sealed pavement to drain into the backfill of subsoil drains.

2. *Interceptor Drains*

Interceptor drains are used where water seeps along a layer of impervious material towards the road formation, and are placed to intercept and drain away this water before it reaches the formation. The most common use of interceptor drains is in cuttings and sidlings (Figure 6.5).

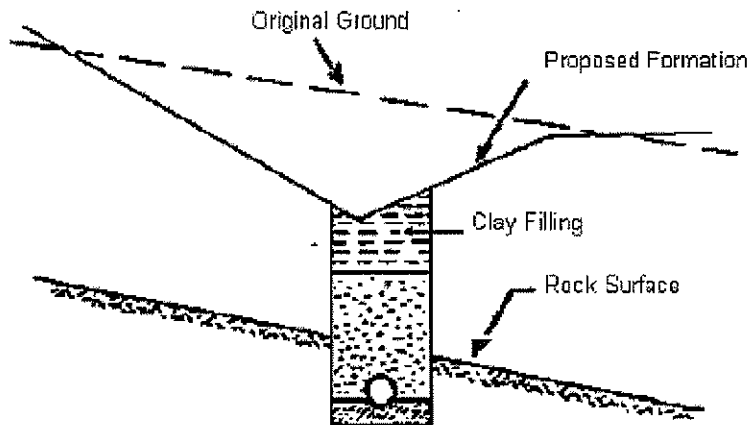


Figure 6.5: Interceptor drain where the objective is to intercept water seeping along an impervious surface under a clay overburden. Source: Transit New Zealand⁸⁰

3. *Pavement Drains*

These drains are actually placed within the road metal, so that they directly drain the basecourse and sub-base layers (unlike type 1 which are aimed primarily at lowering the water table in the subgrade).

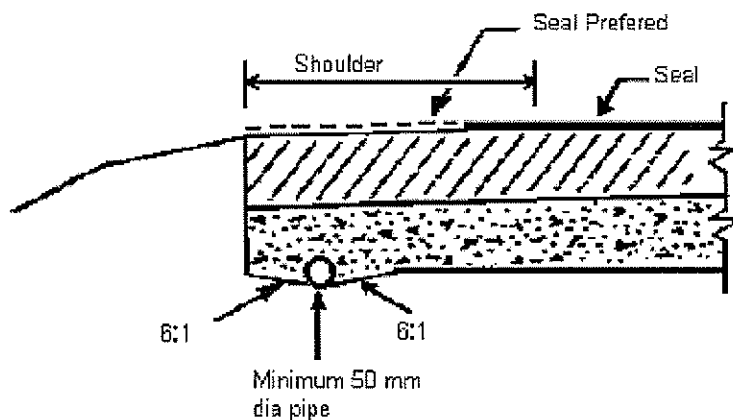


Figure 6.6: Trenchless pavement drain where the objective is to directly drain basecourse and sub-base layers. Source: Transit New Zealand⁸⁰

Because these drains are laid relatively close to the pavement surface, the superimposed wheel loading relative to pipe strength becomes an important consideration.

Smaller diameter plastic pipes are often used in pavement drains.

Pavement drains will frequently be used where kerb and channelling is installed.

6.7.4 Erosion and Scour Prevention

Erosion and scour can be caused by high flow velocities and/or unstabilised soil. It is likely to result in sedimentation downstream, which can reduce the capacity of waterways and adversely effect ecological, amenity and recreational values.

Erosion and scour of the road formation is undesirable, so the road formation must be protected from scour by stabilising shoulders and water tables and by keeping flow velocities to an acceptable level. The inlet and outlet of culverts require special attention as these are areas where flow is concentrated.

6.8 Stormwater Treatment System Design

6.8.1 Introduction

The effects of typical stormwater contaminants on their receiving environments are described in Chapter 5.

Below are descriptions of the various methods that are available for treating stormwater run-off from roads. These may be described as “permanent stormwater treatment systems” since they are for use after construction is complete and there are no more construction effects. Brief technical details and design calculations are provided in each case.

The minimisation and treatment of construction-related sediment discharges is discussed in Section 6.10 of these Guidelines.

6.8.2 Objectives

Overall Objective of Treatment

The overall objective of stormwater treatment is the prevention or mitigation of harmful effects on the environment.

Specific Objectives of the Treatment Method

Before selecting an appropriate treatment method, the problem must be clearly defined and the specific objectives of treatment must be defined. The latter may include one or more of the following:

- Removal of sediment and sediment-bound compounds
- Reduction in litter
- Removal of dissolved nutrients
- Removal of dissolved trace metals
- Removal of free oil and grease
- Reduction of bacteria
- Reduction in oxygen-demanding substances

In most cases the primary objective will be removal of sediment. Aiming for removal of 75% of sediment load is a sensible guideline for most situations⁷⁰ unless consent conditions require a higher removal target.

6.8.3 Procedure

It is recommended that the following steps be followed when determining which treatment method will be most appropriate for a particular site.

Table 6.13: Selection of appropriate treatment for stormwater.

Define:	Reason
What are the contaminants?	Different treatment methods are required to remove different contaminants
What are the required standards?	Water quality must meet local policy and/or consent requirements
What volume/flow rate is expected?	Important for treatment type and size
What space is available?	Some treatment methods require large surface area
What is highest level of water table?	Infiltration type treatment methods may be affected or precluded by high water table
What is depth to bedrock?	Infiltration type treatment methods may be affected or precluded by shallow bedrock
What is the slope of the land?	Some treatment methods require reasonably flat land
What is the soil type?	Some treatment methods rely on moderate to high infiltration rates
What is the expected sediment load?	Important for treatment type and size
What hydraulic head is available?	Head loss across some treatment devices can be high
What treatment options are available?	See Section 6.8.4 for options

6.8.4 Overview of Treatment Methods

Table 6.14: Stormwater treatment methods

Method	Description	Application / Function
Filter Strips	Grassed or vegetated strips (buffer zones) adjacent to roads or watercourses	<ul style="list-style-type: none"> • Appropriate for shallow overland flow • Reduce run-off rate and volume • Removal of sediments and pollutants • See Section 6.8.5.1
Grass Swales	Grass-lined channels for conveying and treating run-off	<ul style="list-style-type: none"> • Reduce run-off rate and volume • Removal of sediments and pollutants • May be used instead of kerb and channel • See Section 6.8.5.2

Table 6.14: Stormwater treatment methods (continued)

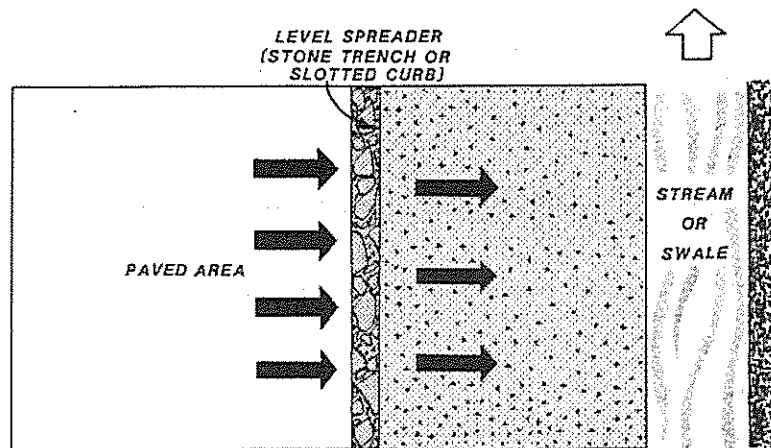
Method	Description	Application / Function
Infiltration Trenches	Shallow excavated trench filled with gravel into which run-off drains to subsoil	<ul style="list-style-type: none"> • Removal of particulates • Catchments with relatively low sediment loads • Reduce run-off rates and volumes • Moderately permeable soils required • Catchments <2 ha • See section 6.8.5.3
Porous Pavements	Coarse graded concrete / asphalt pavement or open concrete blocks allowing infiltration	<ul style="list-style-type: none"> • Pavements subject to low traffic volume and light weight vehicles • Reduce site run-off • Generally used for small catchments • See Section 6.8.5.4
Catch Pits/Sumps	A sump is a stormwater pit with a depressed base that accumulates sediment	<ul style="list-style-type: none"> • Used in roads as entry points to stormwater systems • Reduce sediment load to downstream treatment measures • See Section 6.8.6.1
Litter Baskets, Catchpit Filter Screens and Enviropods	A wire, plastic or nylon mesh 'basket' installed in a stormwater pit/sump to collect litter and/or sediment from a paved surface or within a piped stormwater system	<ul style="list-style-type: none"> • Used in small catchments • Pre-treatment of stormwater • Can be retrofitted to existing system • Suitable for high litter loads • See Section 6.8.6.2
Litter Racks	A series of metal bars located across a channel or pipe to trap litter and debris	<ul style="list-style-type: none"> • Suitable for catchments 8 to 20 ha • Can be retrofitted to existing system • Trap litter upstream of other stormwater treatment measures • See Section 6.8.7.1
Sediment traps	Tank or basin designed to trap coarse sediment	<ul style="list-style-type: none"> • Reduce sediment load to stormwater systems or receiving waters • Reduce sediment load to downstream treatment measures • Generally applicable for catchments >5 ha <p>See Section 6.8.7.2</p>
Gross Pollutant Traps	Sediment trap including a litter rack	<ul style="list-style-type: none"> • Litter removal • Reduce sediment load to stormwater systems or receiving waters • Reduce sediment load to downstream treatment measures • Generally applicable for catchments >5 ha • See Section 6.8.7.3

Table 6.14: Stormwater treatment methods (continued)

Method	Description	Application / Function
Litter Booms	Floating boom with mesh skirt placed in channels or creeks, to collect floating litter debris	<ul style="list-style-type: none"> Remove floating litter Suitable for large catchments See Section 6.8.7.4
Oil / Grit Separators (also known as water quality inlets)	Generally consist of three chambers designed to remove coarse sediment, hydrocarbons, and other floatables	<ul style="list-style-type: none"> Used in areas with significant vehicle pollution and in areas for storing or handling hydrocarbons See Section 6.8.7.5
Extended detention basins	Constructed basin to temporarily store run-off; essentially dry between storm events	<ul style="list-style-type: none"> Settle out sediments and attenuate flood flows Generally used for catchments >3 ha See Section 6.8.7.6
Sand Filters	Generally comprise two chambers: a sediment retention chamber and a filter bed	<ul style="list-style-type: none"> Retention of sediment and other pollutants Appropriate for retrofitting where space is limited Suitable for stabilised, impervious catchments <25 ha See Section 6.8.7.7
Infiltration Basins	Open excavated basins designed to infiltrate run-off through the floor of the basin	<ul style="list-style-type: none"> Removal of particulates and some dissolved pollutants Attenuation of flood flows Recharge of groundwater Reduce run-off rates and volumes Suitable for moderately permeable soils See Section 6.8.7.8
Constructed Wetlands	Generally consist of two parts: an upstream pond with relatively deep water, and downstream wetland with extensive vegetation	<ul style="list-style-type: none"> Retention of fine sediments and nutrients Flood attenuation capacity can be included Generally applicable for large catchments >5 ha See Section 6.8.7.9

6.8.5 Source Control Methods

6.8.5.1 Filter Strips⁸¹



Source: Auckland Regional Council (2002)⁷⁰

Description

Filter strips, also known as buffer zones or buffer strips, are grassed or vegetated areas that treat overland (sheet) flow, often between the road and adjacent drains or watercourses.

Selection Criteria/Advantages

- Appropriate for treating shallow overland flow.
- Can reduce run-off volumes (by infiltration) and delay run-off flow rates (not in design storms).
- Effective at removing particulate matter and associated pollutants (see next).
- Can be used to pre-treat run-off for other SCMs (source control methods).
- Generally apply to catchments smaller than 2ha.

Contaminant Trapping Efficiency

Litter	M	Sediment	H	Nutrients	M
Oxygen demanding material	L	Oil and Grease	H	Bacteria	H

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

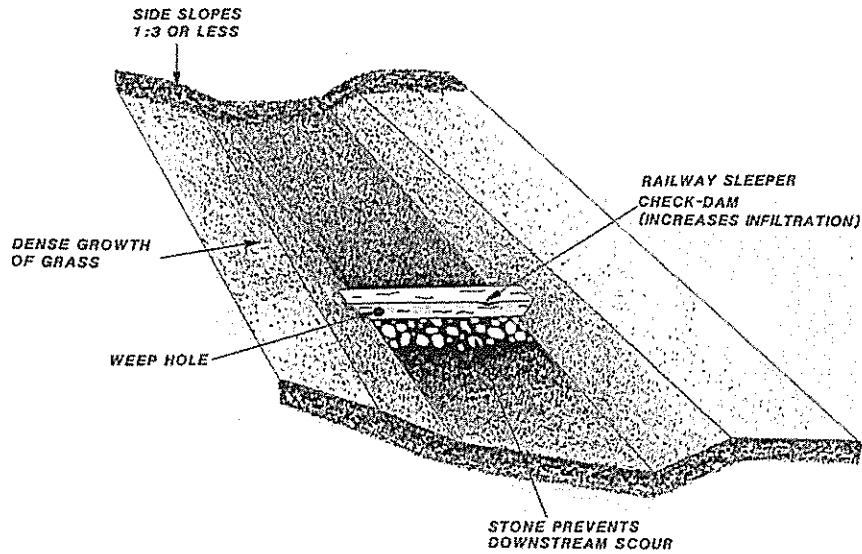
Limitations/Disadvantages

- Limited removal of fine sediment or dissolved pollutants (e.g. dissolved nutrients).
- Requires considerable land areas, and restrictions on vehicular access.
- Adequate sunlight is required; heavy or prolonged shading should be avoided.
- Vegetation needs to be maintained all year.
- Reduced effectiveness for concentrated flows and high flow depths.
- Generally applicable for slopes of up to 5%.

⁸¹ New South Wales Environmental Protection Agency. November 1997. *Managing Urban Stormwater: Treatment Techniques* (Draft).

- High failure rates (largely erosion) have been reported (here and overseas) attributed to poor maintenance and vegetation cover, and difficulties achieving sheet flow and avoiding channelisation.

6.8.5.2 Grass Swales⁸¹



Source: Auckland Regional Council (2002)⁷⁰

Description

Grass swales are grass-lined channels for conveying run-off from roads and other impervious surfaces.

Selection Criteria/Advantages

- Can reduce run-off volumes (by infiltration) and delay run-off flow rates.
- Effective at removing particulate matter and associated pollution.
- Can be used to pre-treat run-off for other STMs.
- More aesthetically appealing than kerb and gutter.
- Generally applicable to catchments less than 2ha and to lower density urban areas.

Contaminant Trapping Efficiency

Litter	M	Sediment	H	Nutrients	M
Oxygen demanding material	L	Oil and Grease	H	Bacteria	H

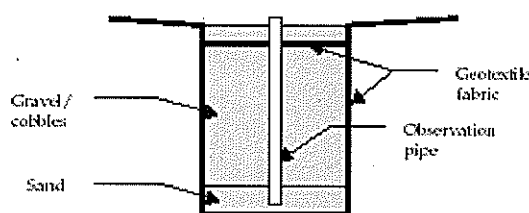
N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Limited removal of fine sediment or dissolved pollutants (e.g. dissolved nutrients).
- Require larger land areas than kerb and gutter, and limited access (e.g. car parking).
- Adequate sunlight is required, and heavy or prolonged shading should be avoided.

- Vegetation needs to be maintained all year.
- Reduced effectiveness for concentrated flows and high flow depths.
- Generally applicable for slopes of up to 5%.
- High failure rates have been reported, attributed to poor maintenance, poor vegetation cover, and difficulties in achieving uniform flow and avoiding channelisation.

6.8.5.3 Infiltration Trenches/Treatment Walls/Trench Filters^{81, 82}



Source: NSW EPA (1997)⁸¹

Description

An infiltration trench is a shallow, excavated trench filled with gravel into which run-off drains to subsoil. Treatment walls and/or trench filters can be installed in infiltration trenches.

Selection Criteria/Advantages

- Principal objective is the removal of particulates and some pollutants.
- Reduces peak run-off rates and volumes, and recharges ground water.
- Appropriate for areas with moderate permeability soils and underground installations.
- Generally applicable for urban residential catchments less than 2ha, particularly roofs.

Pollutant Trapping Efficiency

Litter	N	Sediment	H	Nutrients	M
Oxygen demanding material	H	Oil and Grease	L	Bacteria	H

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

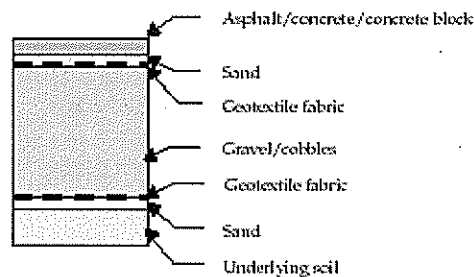
Limitations/Disadvantages

- Risk of sediment clogging the gravel and infiltration surface (pre-treatment is required).
- Should not be used if sediment yields are high or until catchment has been stabilised.
- Risk of ground-water contamination and low dissolved pollutant removal in coarse soils.

⁸² Pandey, S. 2003. Treatment walls go mainstream. *Water & Wastes in NZ 131*: September 2003.

- Potential for metals accumulation in the trench.
- Cannot be placed on steep slopes, fill or unstable areas without appropriate design.
- Inadequate maintenance has been a cause of high failure rates for these devices.

6.8.5.4 Porous Pavements⁸¹



Source: NSW EPA (1997)⁸¹

Description

Porous pavements allow run-off to drain through a coarse (open) graded concrete/asphalt pavement or open concrete blocks, subsequently to infiltrate to the underlying soil.

Selection Criteria/Advantages

- Applicable for pavements subject to low traffic volume and light vehicle weight (e.g. parking areas, pedestrian paths).
- Slope of porous pavement should generally not exceed 5%.
- Reduces site run-off and increases ground-water flow rates.
- Most practical and cost-effective for small catchments, generally 0.1 to 4 ha.

Contaminant Trapping Efficiency

Litter	N	Sediment	M	Nutrients	M
Oxygen demanding material	L-M	Oil and Grease	N	Bacteria	L-M

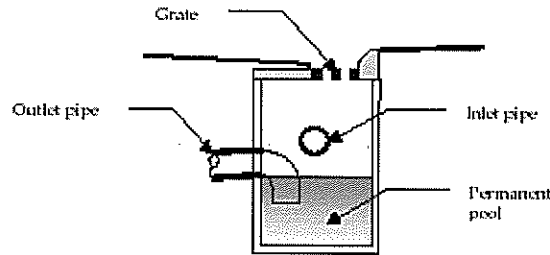
N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- High reported failure rate due to limited infiltration (attributed to partial or total clogging of the pavement surface).
- Inappropriate where catchment or wind erosion generates significant sediment loads.
- Possible risk of ground-water contamination.
- Possible pavement deflection, particularly if traffic loads are significant.
- Inadequate maintenance has been a cause of the high failure rate for these devices.

6.8.6 Top of Pipe Methods

6.8.6.1 Catch Pits / Sumps^{81,83}



Source: NSW EPA (1997)⁸¹

Description

A catch pit or sump is a stormwater pit with a depressed base that catches sediment.

Selection Criteria/Advantages

- Can be used upstream of other stormwater treatment measures to enhance performance.
- Can be appropriate for retrofitting into existing areas, particularly on roads with high traffic volumes.
- Installed below ground and therefore unobtrusive.
- Generally apply to small catchments (less than 1–2 ha).

Contaminant Trapping Efficiency

Litter	L	Sediment	L-M	Nutrients	N
Oxygen demanding material	L	Oil and Grease	L	Bacteria	N

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Potential re-suspension of sediments (depending on design).
- Potential release of nutrients and heavy metals from sediments.
- Need regular maintenance and cleaning to remain efficient.

6.8.6.2 Litter Baskets⁸¹

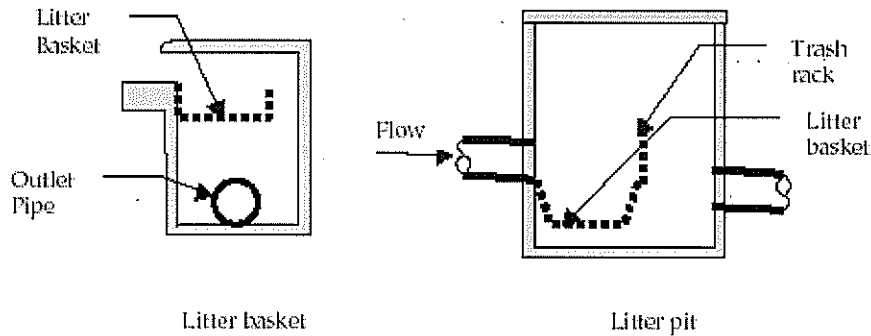
Description

A wire or plastic 'basket' installed in a stormwater pit to collect litter from a paved surface (litter basket) or within a piped stormwater system (litter pit).

Selection Criteria/Advantages

- Can be retrofitted in existing areas.
- Applicable in areas with high litter loads (e.g. shopping centres) or deciduous street trees.

⁸³ Singhal, N., Gunasekera, H.D. 1999. Field evaluation of catchbasin insert performance. *Transfund New Zealand Research Report No. 152*. 37pp.



Source: NSW EPA (1997)⁸¹

- Reduce downstream maintenance requirements.
- Can be used to pre-treat stormwater for other STMs (e.g. constructed wetlands).
- Installed underground to minimise visual impacts.
- Litter baskets are generally applicable for small catchments (<1 to 2 ha); litter pits can be used for larger catchments (up to say 150 ha).

Contaminant Trapping Efficiency

Litter	M	Sediment	L	Nutrients	N
Oxygen demanding material	M	Oil and Grease	N	Bacteria	N

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

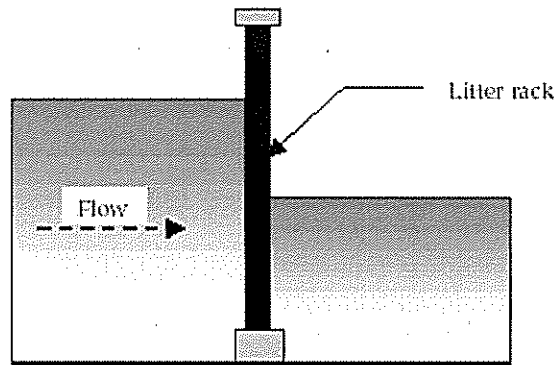
Limitations/Disadvantages

- Potential for litter pits to aggravate upstream flooding if blocked by litter and vegetation (loss of pit inlet capacity); design of grid size is critical (often too small).
- Potential for litter baskets to reduce pit inlet capacity if located close to inlet (as shown on the diagram).
- Hydraulic head loss occurs, particularly for litter pits.
- Potential loss of pit inlet capacity because of litter basket, particularly on steeper slopes.
- Possible odour problems.
- Previously caught material can be re-mobilised if overtopping occurs.
- Require very regular maintenance/cleaning.

6.8.7 End of Pipe Methods

Typically the methods identified in this section are most commonly applied at the end of stormwater pipes. However they can sometimes be effectively applied further up the stormwater system.

6.8.7.1 Litter Racks ⁸¹



Description

Litter racks (or trash racks) are a series of metal bars located across a channel or pipe to trap litter and debris.

Selection Criteria/Advantages

- Litter racks can be used to trap litter upstream of other stormwater treatment measures (possibly to prevent blocking at basin outlets) or waterways.
- They might be appropriate for retrofitting into existing areas.
- Reduced downstream maintenance requirements.
- They are generally applicable for catchments between 8 and 20 ha in area.

Contaminant Trapping Efficiency

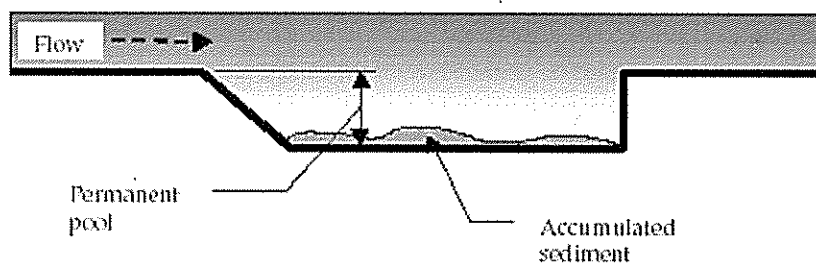
Litter	L	Sediment	L	Nutrients	N
Oxygen demanding material	L	Oil and Grease	N	Bacteria	N

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Racks have a tendency to be blocked by debris.
- Potential to aggravate upstream flooding when blocked.
- Sediment can be trapped upstream of the rack.
- Collected litter can move upstream along a tidal channel due to tidal influence.
- Appearance of the rack and trapped litter can be obtrusive.
- Potential odours and health risk to workers when handling litter.
- Possible safety risk when installed in channels.
- Some litter will break down after approximately 2 weeks, releasing pollutants.
- Previously caught material can be re-mobilised when overtopping occurs.
- Require regular cleaning and can be difficult to clean and maintain.

6.8.7.2 Sediment Traps ⁸¹



Description

Sediment traps (sometimes known as sediment basins or sediment forebays) are designed to trap coarse sediment and can take the form of a formal “tank” or a less formal pond.

Selection Criteria/Advantages

- Trap coarse sediments upstream of a treatment measure such as a wet basin or constructed wetland.
- Reduce coarse sediment loads to stormwater systems or receiving waters.
- Can be installed underground.
- Generally applicable to catchments greater than 5 ha.

Contaminant Trapping Efficiency

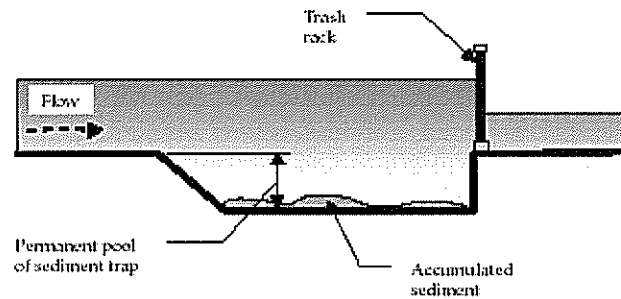
Litter	N	Sediment	H	Nutrients	N
Oxygen demanding material	L	Oil and Grease	N	Bacteria	N

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Limited removal of fine sediment or soluble pollutants.
- Above-ground sediment traps (particularly in tank form) can be visually unattractive.
- Trapping of excessive sediment can result in downstream channel erosion.
- The sediments themselves and/or pollutants from within the sediments can be re-mobilised.
- Potential for mosquito breeding.
- Periodically need removal of deposits.

6.8.7.3 Gross Pollutant Traps ⁸¹



Description

A gross pollutant trap (GPT) is a sediment trap with a litter (or trash) rack. It is usually located at the downstream end of the pipe.

Selection Criteria/Advantages

- GPTs trap coarse sediments before they enter a wetland, pond, or other stormwater treatment device, thereby preserving capacity and pond/wetland shape.
- They concentrate litter at a single location for ready removal.
- They may be appropriate for retrofitting into existing urban areas.
- Small traps can be located underground, minimising visual impacts.
- They are generally suitable for catchments greater than approximately 6 to 8 ha.

Contaminant Trapping Efficiency

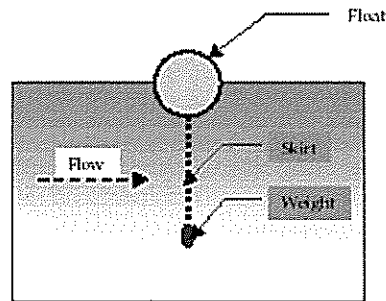
Litter	L	Sediment	M-H	Nutrients	L
Oxygen demanding material	L	Oil and Grease	N	Bacteria	L

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Litter racks are prone to blockage by debris.
- Potential to aggravate upstream flooding if the litter rack becomes blocked.
- The appearance of the trap and litter can be obtrusive.
- Potential odours and health risk to workers when handling litter.
- Possible safety risk when installed in channels.
- Previously caught material can be re-mobilised when overtopping occurs.
- Litter can move upstream if installed in a tidal channel.
- Difficult and expensive to clean.

6.8.7.4 Litter Booms⁸¹



Source: NSW EPA (1997)⁸¹

Description

Litter booms are floating booms with mesh skirts placed in channels or creeks to collect floating litter and debris.

Selection Criteria/Advantages

- Used to remove floating litter.
- Enhance aesthetic appeal and recreational potential of downstream waterways.
- Mobile and can be appropriate for retrofitting into existing areas.
- Collect litters at a single location.
- No hydraulic head loss.
- Boom can rise and fall with changing water level.

Contaminant Trapping Efficiency

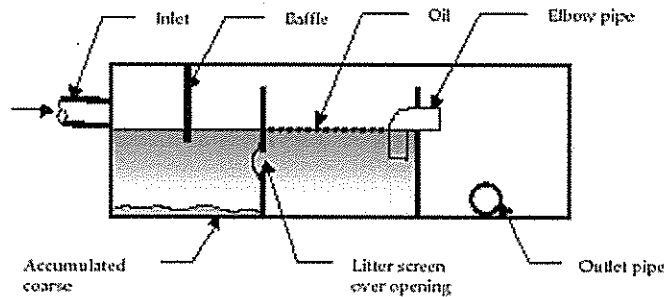
Litter	L	Sediment	N	Nutrients	N
Oxygen demanding material	N	Oil and Grease	L	Bacteria	N

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Only traps floating litter and debris (may be a small proportion of the total load).
- Floating and neutrally buoyant litter can be swept under the skirt during high flows.
- Impacts from large objects such as branches or boats can reduce boom effectiveness.
- Litter can be blown over the boom's collar in high winds.
- Maintenance can be difficult as most booms must be cleaned by boat.
- Potential for vandalism.
- Possibility of sinking due to marine growth.
- Collected litter can move upstream along a tidal channel due to tidal flows.
- Low visual amenity.

6.8.7.5 Oil / Grit Separators ⁸¹



Source: NSW EPA (1997)⁸¹

Note: An alternative would be to put the litter rack at the inlet. Oils etc. would accumulate on the surface of the first chamber if there is no flow over the top into the second chamber.

Description

Oil/grit separators generally consist of three underground retention chambers designed to remove coarse sediment and hydrocarbons.

Selection Criteria/Advantages

- Appropriate for treating stormwater from areas expected to have significant vehicular pollution (e.g. parking lots), particularly hydrocarbons. They can also trap litter.
- Can also be used for treating stormwater from areas storing or handling petroleum products (e.g. service stations and petroleum depots).
- Can be appropriate for retrofitting into existing areas.
- Installed below ground and therefore unobtrusive.
- Applicable for small catchments (generally less than 2,500 m²).

Contaminant Trapping Efficiency

Litter	L-M	Sediment	M	Nutrients	L
Oxygen demanding material	L	Oil and Grease	M	Bacteria	L

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Limited removal of fine sediment or soluble pollutants.
- When turbulent stormwater enters the chambers, this action may re-suspend particulates or entrain floating oil. A high flow bypass is required.
- Trapped debris is likely to have high concentrations of pollutants, possibly toxicants.
- Potential safety hazard to maintenance personnel.
- Potential release of nutrients and heavy metals from sediments.
- Need to be regularly cleaned to achieve design objectives.

6.8.7.6 Extended Detention Basins ⁸¹

Description

Extended detention basins commonly store run-off for 1–2 days and drain to an essentially dry basin between storm events.

Selection Criteria/Advantages

- Principal objective is the retention of particulates (flow detention with retention of coarse sediments).
- Could be used where the site area precludes the use of a constructed wetland.
- Potential for multiple use if basin drains between storm events (e.g. sports field or park).
- Detention of run-off reduces the frequency of erosive flows downstream.
- Generally appropriate for catchments over 3–6 ha (depends on minimum outlet size); in principle can be used for all sizes.

Contaminant Trapping Efficiency

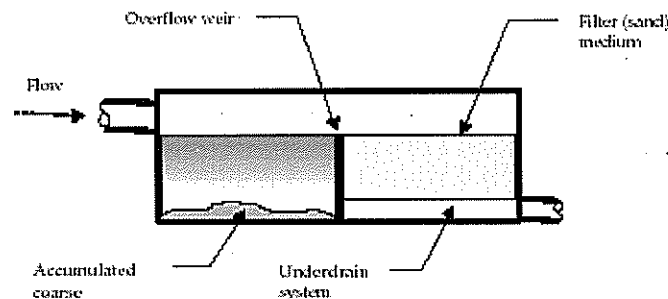
Litter	L	Sediment	M	Nutrients	L
Oxygen demanding material	L	Oil and Grease	L	Bacteria	H

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Limited removal of fine sediment or dissolved pollutants (e.g. dissolved nutrients).
- Potentially lower efficiency for events smaller than the design event.
- Outlet structures are prone to clogging (if no litter removal pre-treatment is provided). Depends on type.
- Potential for erosion and re-suspension of deposited sediment in the basin floor.
- Possible safety hazard due to intermittent nature of flooding.
- Possible maintenance problems (normally not excessively wet, and often have an incised channel for low flows).

6.8.7.7 Sand Filters ⁸¹



Description

Sand filters comprise a bed of sand (or other medium) through which run-off is passed. The filtered run-off is collected by an underdrain system.

Selection Criteria/Advantages

- Principal objective is the retention of particulates (also aerobic treatment – see Efficiency below).
- Appropriate for retrofitting, sites with space limitations and underground installation.
- Generally suitable for stabilised and largely impervious catchments up to 25 ha.

Contaminant Trapping Efficiency

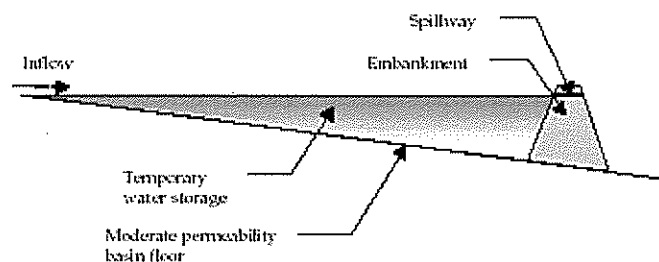
Litter	L	Sediment	M	Nutrients	M
Oxygen demanding material	M	Oil and Grease	M	Bacteria	H

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Limited removal of dissolved pollutants (e.g. dissolved nutrients).
- Upstream litter and coarse sediment removal is required to minimise clogging.
- Easily clogged, and effectiveness is highly dependent upon frequent maintenance.
- High head loss and relatively low flow rates through the filter.
- Large sand filters without grass cover can be unattractive in residential areas.

6.8.7.8 Infiltration Basins⁸¹



Description

Stormwater infiltration basins are open excavated basins that are designed to infiltrate run-off through the floor of the basin.

Selection Criteria/Advantages

- Principal objective is the removal of particulates and some dissolved pollutants.
- Reduces peak run-off rates and volumes, and recharges ground water.
- Appropriate for areas with moderate permeability soils.
- Generally applicable for stabilised urban residential catchments less than 5 ha.

Contaminant Trapping Efficiency

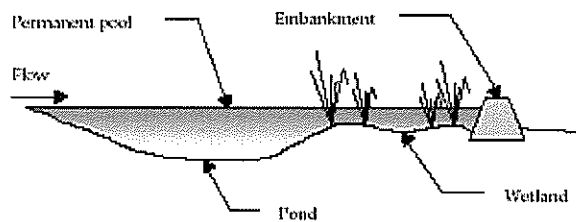
Litter	L	Sediment	H	Nutrients	M
Oxygen demanding material	M	Oil and Grease	L	Bacteria	H

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Risk of sediment clogging the infiltration surface (pre-treatment is required).
- Should not be used (a) until catchment has been stabilised, or (b) when sediment yields are high.
- Risk of ground-water contamination and low dissolved pollutant removal in coarse soils.
- Potential for metals accumulation in the base of the basin.
- Cannot be placed on steep slopes, fill or unstable areas.
- Large area of land needed.
- Inadequate maintenance has been a cause of the high failure rate for these basins.

6.8.7.9 Constructed Wetlands ⁸¹



Description

A constructed wetland system (or a water quality control pond or wet basin) commonly has two components: an upstream pond with relatively deep water and littoral macrophytes, and a downstream wetland with extensive macrophyte vegetation.

Selection Criteria/Advantages

- Principal water quality objective is the retention of fine sediment and nutrients.
- Comparatively high retention efficiency for a range of run-off event sizes.
- Potential for multi-objective designs to provide habitat, recreational and visual amenity.
- A flood storage component can be included to attenuate downstream flows.
- Generally applicable for catchments larger than 5–10 ha.

Contaminant Trapping Efficiency

Litter	L	Sediment	M-H	Nutrients	M
Oxygen demanding material	M-H	Oil and Grease	M	Bacteria	M

N=zero efficiency; L=low efficiency; M=moderate efficiency; H=high efficiency

Limitations/Disadvantages

- Require pre-treatment to remove coarse sediment or incorporate coarse sediment removal in the design.
- Reliable inflow needed to remain ‘wet’, unless designed as an ephemeral wetland.

- Potential impact on public health and safety from a physical, chemical or biological (e.g. mosquito-borne disease) perspective.
- Could have an impact on groundwater, or groundwater could have an impact on the wetland.
- Relatively large land requirement.

6.8.8 Proprietary Systems

A range of proprietary systems are now available on the market. These need careful evaluation to ensure they will provide an appropriate solution for the stormwater management system being addressed.

The following points need to be addressed when evaluating a proprietary system:

- A review of “fit for purpose” of the particular system
- Option assessment (Capital Expenditure and Operational Expenditure)
- Independent review of performance specification and capacity check
- Constructability and space requirements for a new retrofit system and new developments
- Independent review of maintenance requirements
- Ease of maintenance and access for maintenance considerations
- Overflow considerations

Proprietary systems typically available on the market include:

- First flush systems
- Sand filter systems
- Gross pollutant traps
- Catchpits
- Oil and grease interceptors
- Treatment wall filter materials
- Litter racks

NZ Company Contacts for Proprietary Stormwater Management/Treatment Products.

Company	Website
Bisleys Environmental	http://www.bisleys.net
Ecosol	http://www.ecosol.com.au
Eco Solutions	http://www.enviropod.com
Geotech Systems	http://www.geotechsystems.co.nz
Humes	http://www.humes.co.nz
Hynds Environmental Systems	http://www.hynds.co.nz
Ingal Environmental Services	(email) info@ingalenviro.com

6.8.9 Sustainable Urban Drainage (SUD) Methods

As outlined in Section 3.3.6 of these Guidelines, SUD methods adopt a holistic approach to stormwater management. When the opportunity arises, RCAs need to give consideration to a SUD approach. Guidance to SUD solutions is given in Berry (2002) and CIRIA Report 523 (2000) (see Section 3.3.6 or Bibliography for references).

6.9 Retrofitting of Stormwater Control and Treatment Systems

As stormwater discharge consents come up for renewal, more demands will come on the road network manager for retrofitting stormwater control and treatment systems. Each case will be site-specific and the “best practicable option” will need to be adopted (refer Section 1.9 of these Guidelines).

6.10 Erosion and Sediment Control during Construction

Overall Objective

- The overall objective is to minimise sediment run-off during the construction period.

Specific Objectives

- Prevention of erosion.
- Removal of sediment and sediment-bound compounds from run-off.
- Prevention/minimisation of harmful effects on the environment.

Sediment control measures during construction are generally specified in regional resource management plans and/or TA codes of practice for land development.

Issues

Factors that should be considered when deciding on the level of erosion/sediment control measures include:

- Climate
- Catchment
- Size of site/area of disturbed land
- Slope of site
- Receiving environment

Receiving Environment

The Regional Plan for each region will give general guidance on what level of protection is required for the receiving environment. However it is unlikely that the Regional Plan will go into specific methods for erosion/sediment control.

Guidelines

Auckland Regional Council’s TP90⁸⁴ is a document written specifically to deal with erosion and sediment control issues (but not specifically for roading). Although written specifically for the Auckland region, it can be adapted to suit much of New Zealand.

⁸⁴ Auckland Regional Council. 1992. Erosion and Sediment Control – Guidelines for Land Disturbing Activities. *ARC Technical Publication 90*.

TP90's "Ten Commandments" for erosion and sediment control are:

1	Minimise disturbance	Only disturb areas that must be disturbed.
2	Stage construction	Progressively undertake earthworks in small units at a time.
3	Protect steep slopes	Avoid existing steep slopes, stabilise any steep slopes that are disturbed.
4	Protect watercourses	Map existing watercourses and proposed drainage channels, avoid clearing adjacent to any watercourse.
5	Stabilise exposed areas rapidly	Use geotextiles, hydroseeding, native shrub planting, etc., to stabilise exposed areas.
6	Install perimeter controls	Prevent clean water from outside the site from entering.
7	Employ detention devices	Capture sediment before it leaves the site.
8	Ensure registration of contractors	Relates to the importance of experienced contractors.
9	Make sure the plan evolves	Changing site / weather conditions may require controls to be modified.
10	Assess and adjust	Inspect, monitor and maintain control measures.

Minimise Area of Disturbance

The most effective form of erosion control is to minimise the area of disturbance, retaining as much existing vegetation as possible. This is especially important on steep slopes or in the vicinity of watercourses, where no single measure will adequately control the erosion and transport of sediment, and where receiving environments may be highly sensitive.⁸⁴

Timing

Erosion and sediment control devices should be in place before earthworks commence and should be removed only after the site has been fully stabilised to protect it from erosion.⁸⁴

Methods

TP90⁸⁴ gives detailed information about the following erosion and sediment control practices, including their purpose, application, design/construction specifications, and maintenance.

Erosion control methods:

- Run-off diversions/ bunds
- Contour drains
- Benched slopes
- Rock check dams
- Topsoiling
- Temporary and permanent seeding
- Hydroseeding
- Mulching
- Turfing

- Geosynthetic erosion control systems
- Stabilised construction entrance

- Pipe drop structure / Flume
- Level spreader
- Surface roughening

Sediment control methods:

- Sediment retention pond
- Silt fences
- Hay bale barriers
- Stormwater inlet protection
- Earth bund
- Sump / Sediment pit

TP90 also contains guidelines for working in a watercourse.

6.11 Maintenance of Treatment Devices and Conveyance Structures

It is essential that stormwater treatment devices and conveyance structures are appropriately maintained to ensure their long-term effectiveness. If the stormwater facilities are not maintained to an appropriate standard, problems such as erosion, instability, flooding and degradation of receiving water may occur.

The following maintenance considerations should be made when designing stormwater treatment / conveyance devices:

Table 6.15: Maintenance issues.

Phase	Issue	Details
Design	Access	Design should allow for access to the facilities to allow maintenance activities to be carried out.
	Health and safety	Health and safety issues should be considered during the design of the facilities. A safe method of maintaining the facilities is required.
	Life-cycle costs	Maintenance requirements* should be considered during the design phase. Cost of maintenance and total life-cycle costs can then be considered before committing capital to the project.
Operation	Monitoring	Monitoring of sediment/contaminant build-up is essential to ensure maintenance is carried out before the system becomes overloaded.
	Disposal	A disposal system/site for the material collected from treatment facilities must be considered. These materials may be highly polluted and may not be suitable for landfill application.
	Maintenance	The different stormwater treatment measures have differing maintenance requirements. A reference is given below.

* Auckland Regional Council's TP10⁷⁰ gives a good description of the maintenance requirements for the various treatment methods. This should be consulted for further information.

6.12 Life-Cycle Costing Considerations

In selecting a stormwater treatment system, consideration needs to be given to full life-cycle costs, as there is more to life-cycle costs of stormwater treatment systems than general maintenance and monitoring. Different systems will have variable life cycle costs, depending on specific site conditions. However, a number of potential costs need to be considered and these can include the following:

Planning/Construction Costs

- Initial consents
- Existing pre construction monitoring
- Design
- Risk assessment
- Risk and liability
- Capital costs – construction and land

Establishment Costs

- Risk and liability
- Education of users
- Intensive monitoring of performance and establishment

Post-Establishment Costs

- Possible fine tuning, modification, or complete overhaul depending on performance monitoring during establishment
- Re-consenting at given intervals
- Performance and condition monitoring
- General maintenance
- Disposal of polluted material, e.g. sediment and filter material
- Risk and liability
- Replacement/renewal and refurbishment of parts and components, e.g. revegetation, acts of vandalism
- Eventual re-sizing of facility to accommodate increased flows resulting from climate change

Consideration should be given to the reduced indirect costs to the community as a result of the implementation of some of the more innovative low impact methods (e.g. SUD methods). These can include the following:

- Reduced pipe infrastructure and engineered solutions downstream
- Reduced damage resulting from flooding
- Reduced downstream pollution
- Reduced downstream erosion

Consideration should also be given to the indirect benefits resulting from the implementation of such methods, many of which are intangible. These can include the following:

- Benefit to the general health of the environment, e.g. enhanced bio-diversity resulting from wetlands
- Aesthetic value of many treatment devices such as ponds and wetlands

- Enhanced property values resulting from aesthetically pleasing environments
- Enhanced 'clean green' image of cities and towns

Reduced indirect costs and intangible benefits should be considered against the life-cycle costs of the treatment system. While it may be possible to place a monetary value on the costs of such devices, some attempt should be made to assess the intangible benefits and to factor such benefits into the overall costs.

Depending on the type of system, the weighting applied to the different costs will vary. Some systems require more extensive monitoring programmes, others may require greater maintenance. In monetary terms, life-cycle costs will vary across different regions and across different sites, depending on the detail of designs and the levels of stormwater to be treated.

The following table outlines, in general terms, the possible extent and level of life-cycle costs for different treatment systems.

Table 6.16: Indicative life-cycle costs of stormwater treatment systems.

Treatment System	Life-Cycle Costs
Filter Strips	Low
Grass Swales	Medium
Infiltration Trenches	Low to Medium
Porous Pavements	Medium to High
Catch Pits/Sumps	Low
Litter Baskets, Catchpit Filters, Screens and Enviropods	Low
Litter Racks	Low
Sediment Traps	Low
Gross Pollutant Traps	Low
Litter Booms	Low
Oil/Grit Separators	Medium
Extended Detention Basins	Medium
Sand Filters	Low to Medium
Infiltration Basins	Medium to High
Constructed Wetlands	High
Ponds	High

It has been suggested that more extensive features such as wetlands and detention basins/ponds will actually increase in terms of their asset value over time as their maintenance costs reduce. This differs from traditional methods such as pipelines and ditches, which require ongoing maintenance and eventual renewal. It is difficult to affix a monetary value to the benefits of SUD-type approaches, but some attempt should be made.

It should be understood that, although some treatment systems have high life-cycle costs relative to other methods, this is typically a result of the extensive nature of the treatment provided in terms of stormwater quantity. For example, wetlands and ponds may require more extensive maintenance due to the nature of their vegetation

requirements and large area, relative to say infiltration trenches that can be left for several years before significant maintenance is required.

Maintenance Costs

Some of the main issues pertaining to the maintenance of stormwater treatment systems relate to their performance, safety and aesthetics. Different methods have different maintenance requirements. For example, those that use vegetation to enhance the aesthetic of the treatment facility need that vegetation maintained, while those that aid the settlement of sediment need that sediment removed periodically. Ponds, for example, may periodically require both.

The following Table 6.17 provides an indication of the possible maintenance issues pertaining to the stormwater treatment methods outlined in this Guideline. It is by no means an exhaustive list and it should be understood that detailed design and site-specific issues largely determine the maintenance required.

Monitoring Costs

The frequency and extent of monitoring appropriate to different treatment methods varies. Performance in monitoring usually involves an assessment of water quality and discharge rate. However, some attempt should be made to monitor components of treatment systems that may not necessarily reflect their performance. For example, health and safety issues, development of ecological diversity (ponds, wetlands) and treatment efficiencies.

The following Table 6.18 provides an indication of what monitoring may be required for various treatment systems. It is by no means an exhaustive list and it should be understood that detailed design and site-specific issues can largely determine the monitoring required.

Table 6.17 Maintenance requirements for different treatment methods

Treatment Systems	Maintenance Items	Timing
Filter Strips	<ul style="list-style-type: none"> Maintenance of vegetation Replacement of filtration material Trash and debris removal 	<ul style="list-style-type: none"> Ongoing Periodic Ongoing
Grass Swales	<ul style="list-style-type: none"> Maintenance of vegetation Mowing of grass Replacement of topsoil Re-sowing of vegetation Trash and debris removal 	<ul style="list-style-type: none"> Ongoing Fortnightly – monthly (dependent on season) Eventual – pollutant concentration dependent Possibly ongoing to full eventual replacement Ongoing
Infiltration Trenches	<ul style="list-style-type: none"> Sediment removal Replacement of filtration material Trash and debris removal 	<ul style="list-style-type: none"> Periodic (site dependent) Periodic (site dependent)/eventual Ongoing
Porous Pavements	<ul style="list-style-type: none"> Cleansing (sweeping) Re-laying of surface and subsurface Trash and debris removal 	<ul style="list-style-type: none"> 6-12 months Eventual (performance related) Ongoing
Catch Pits/Sumps	<ul style="list-style-type: none"> Trash and debris removal De-sedimentation 	<ul style="list-style-type: none"> Ongoing Periodic
Litter baskets, Catchpit Filters, Screens and Enviropods	<ul style="list-style-type: none"> Screen/basket/filter cleansing, debris removal Maintenance of safety features 	<ul style="list-style-type: none"> Regular As required
Litter Racks	<ul style="list-style-type: none"> Debris removal Maintenance of safety features 	<ul style="list-style-type: none"> Regular As required
Sediment Traps	<ul style="list-style-type: none"> Sediment removal Cleansing Trash and debris removal 	<ul style="list-style-type: none"> Periodic 6-24 monthly Ongoing
Gross Pollutant Traps	<ul style="list-style-type: none"> Debris/sediment removal Maintenance of safety features 	<ul style="list-style-type: none"> Regular As required
Litter Booms	<ul style="list-style-type: none"> Debris removal 	<ul style="list-style-type: none"> Regular

Table 6.17 Maintenance requirements for different treatment methods (continued)

Treatment Systems	Maintenance Items	Timing
Oil/Grit Separators	<ul style="list-style-type: none"> • Inspections and general maintenance • Removal of oil layer • Sludge removal • Maintenance of vent 	<ul style="list-style-type: none"> • Regular • Flowing storm events • Regular/periodic • Ongoing
Extended Detention basins	<ul style="list-style-type: none"> • Mowing of grassed banks and basin • Vegetation maintenance, e.g. trimming, pest/weed control • Embankment maintenance, e.g. erosion protection • De-sedimentation • Trash and debris removal • Maintenance of safety features 	<ul style="list-style-type: none"> • Fortnightly – monthly (dependent on season) • Regular • Eventual • Periodic • Ongoing • As required
Sand Filters	<ul style="list-style-type: none"> • Replacement of filtration material • De-sedimentation • Aesthetic maintenance, e.g. graffiti removal • Filter clean out • Structural maintenance • Maintenance of safety features 	<ul style="list-style-type: none"> • Periodic • 2-10 yearly • Ongoing • 6-12 monthly • As required • As required
Infiltration Basins	<ul style="list-style-type: none"> • Mowing of grassed banks and basin • Vegetation maintenance, e.g. trimming, pest/weed control • Embankment maintenance, e.g. erosion protection • Tilling/discing/aerating base soils • Trash and debris removal • Maintenance of safety features 	<ul style="list-style-type: none"> • Fortnightly – monthly (dependent on season) • Regular • Eventual • Periodic • Ongoing • As required

Table 6.17 Maintenance requirements for different treatment methods (continued)

Treatment Systems	Maintenance Items	Timing
Constructed Wetlands	<ul style="list-style-type: none"> • Vegetation, plant loss replacement • Sediment removal • Pest control, e.g. invasive weeds, mosquitoes • Vegetation control, e.g. thinning • Trash and debris removal • Maintenance of safety features 	<ul style="list-style-type: none"> • Ongoing • Periodic • Ongoing, increased importance during establishment • 1-2 yearly • Ongoing • As required
Ponds	<ul style="list-style-type: none"> • Vegetation, plant loss replacement • Sediment removal • Pest control, e.g. invasive weeds, mosquitoes • Vegetation control, e.g. thinning • Aesthetic maintenance • Trash and debris removal • Maintenance of mechanical components, e.g. valves, gates, locks • Structural repairs, e.g. embankments • Removal of trees • Maintenance of safety features 	<ul style="list-style-type: none"> • Ongoing • Periodic • Ongoing, increased importance during establishment • 1-2 yearly • Ongoing • Ongoing • Regular • As necessary • Eventual • As required

Table 6.18 Monitoring requirements of different treatment methods

Treatment Systems	Monitoring Type	Timing
Filter Strips	<ul style="list-style-type: none"> Vegetation condition monitoring Performance monitoring – water quality (surface and ground water) Pollutant levels in topsoil/vegetation 	<ul style="list-style-type: none"> Regular Regular Annual
Grass Swales	<ul style="list-style-type: none"> Vegetation condition monitoring Performance monitoring – water quality (surface and ground water) Sedimentation monitoring 	<ul style="list-style-type: none"> Regular Regular Annual
Infiltration Trenches	<ul style="list-style-type: none"> Performance monitoring – water quality (surface and ground water) Pollutant levels in filter material Ground-water level monitoring Infiltration rate monitoring 	<ul style="list-style-type: none"> Regular Annual Regular Annual
Porous Pavements	<ul style="list-style-type: none"> Sedimentation monitoring Pollutant levels in filter material Infiltration rate monitoring 	<ul style="list-style-type: none"> Annual Annual Annual
Catch Pits/Sumps	<ul style="list-style-type: none"> Sedimentation monitoring 	<ul style="list-style-type: none"> Regular
Litter baskets, Catchpit Filters, Screens and Enviropods	<ul style="list-style-type: none"> General performance 	<ul style="list-style-type: none"> Periodic
Litter Racks	<ul style="list-style-type: none"> General performance 	<ul style="list-style-type: none"> Periodic
Sediment Traps	<ul style="list-style-type: none"> Sedimentation monitoring Performance monitoring – water quality 	<ul style="list-style-type: none"> Regular Regular
Gross Pollutant Traps	<ul style="list-style-type: none"> General performance 	<ul style="list-style-type: none"> Ongoing
Litter Booms	<ul style="list-style-type: none"> General performance 	<ul style="list-style-type: none"> Ongoing
Oil/Grit Separators	<ul style="list-style-type: none"> Performance monitoring – water quality 	<ul style="list-style-type: none"> Ongoing

Table 6.18 Monitoring requirements of different treatment methods (continued).

Treatment Systems	Monitoring Type	Timing
Extended Detention basins	<ul style="list-style-type: none"> • Soil erosion monitoring • Monitoring of sedimentation • Inlet/outlet inspections • Monitoring aesthetic performance • Vegetation condition monitoring • Performance monitoring 	<ul style="list-style-type: none"> • Annual – Periodic (following large events) • Annual • Annual • Annual • Annual • Annual • Regular
Sand Filters	<ul style="list-style-type: none"> • Performance monitoring – water quality • Pollutant levels in filter material 	<ul style="list-style-type: none"> • Regular • Annual
Infiltration Basins	<ul style="list-style-type: none"> • Soil erosion monitoring • Infiltration rate monitoring • Monitoring aesthetic performance • Sediment monitoring – pollutants and sedimentation levels • Vegetation condition monitoring • Performance monitoring • Ground-water level monitoring 	<ul style="list-style-type: none"> • Annual – Periodic (following large events) • Annual • Annual • Annual • Annual • Annual • Regular • Regular
Constructed Wetlands	<ul style="list-style-type: none"> • Soil erosion monitoring • Monitoring aesthetic performance • Sedimentation monitoring • Vegetation monitoring • Performance monitoring – water quality (surface + ground water) • Ground-water level monitoring • Soil moisture/water level monitoring 	<ul style="list-style-type: none"> • Annual – Periodic (following large events) • Annual • Annual – Regular during establishment • Regular • Regular • Regular • Regular
Ponds	<ul style="list-style-type: none"> • Soil erosion monitoring • Monitoring aesthetic performance • Sedimentation monitoring • Vegetation monitoring, e.g. condition, diversity, etc. • Performance monitoring – water quality (surface + ground water) 	<ul style="list-style-type: none"> • Annual – Periodic (following large events) • Annual • Annual • Monthly • Regular

7. Bibliography

7.1 Legal Framework Surrounding the Management of Stormwater Run-off from Roads in New Zealand

Building Act 1991. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Building Regulations 1992. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Health Act 1956. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Land Drainage Act 1908. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Land Transport Management Act 2003. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Local Government Act 1974. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Local Government Act 2002. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Public Finance Act 1989. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Public Works Act 1981. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Resource Management Act 1991. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Soil Conservation and Rivers Control Act 1941. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Transit New Zealand Act 1989. Act of Parliament, New Zealand. New Zealand Government, Wellington.

Trespass Act 1980. Act of Parliament, New Zealand. New Zealand Government, Wellington.

7.2 Regulatory and Non-regulatory Stormwater Management Instruments

Auckland Regional Council. 1999. *Auckland Regional Policy Statement*. Auckland Regional Council, Auckland, New Zealand.

Auckland Regional Council. 1998. *Auckland Region Urban Stormwater Management Project – Strategy Statement*. Prepared by the Territorial Authorities – Auckland Regional Council Stormwater Liaison Group, Auckland, New Zealand.

Auckland Regional Council. 1997. *Stormwater Management Strategy. Technical Report No. 1: Background Report*. Prepared by the Territorial Authorities Directors Group, Auckland, New Zealand.

Auckland Regional Council. 1997. *Stormwater Management Strategy: Technical Report No. 2: Analysis of Catchment and Receiving Environments*. Prepared by the Territorial Authorities Directors Group, Auckland, New Zealand.

Auckland Regional Council. 1997. *Stormwater Management Strategy: Technical Report No. 5: Methods and Options for Stormwater Management*. Prepared by the Territorial Authorities Directors Group, Auckland, New Zealand.

Auckland Regional Council. 1997. *Stormwater Management Strategy: Technical Report No. 6: Costs and Benefits of Stormwater Management*. Prepared by the Territorial Authorities Directors Group, Auckland, New Zealand.

Beca Steven. 1998. *North Shore City Stormwater Strategy Statement*. Prepared for North Shore City Council, New Zealand.

Berry, C. 2002. *Sustainable Urban Drainage: UK Experience and Practical Application in New Zealand*. Paper presented to New Zealand Water and Wastes Association Annual Conference and Expo. Christchurch, New Zealand, 25-27 September, 2002.

Center for Watershed Protection. 2001. *New York State: Stormwater Management Design Manual*. New York State Department of Environmental Conservation, Albany, USA.

Christchurch City Council. 2003. *Waterways, Wetlands and Drainage Guide: Part A: Visions*. Christchurch City Council, Christchurch, New Zealand.

Christchurch City Council. 2000. *Natural Asset Management Strategy for Waterways and Wetlands*. Christchurch City Council, Christchurch, New Zealand.

CIRIA. 2004 (March 30 – last update). *SUDS: Sustainable Drainage Systems: Promoting Good Practice – a CIRIA Initiative* [Online]. Available: <http://www.ciria.org/sud/>

CIRIA. 2001. *CIRIA Report 523: Sustainable Urban Drainage: Best Practice Manual for England Scotland Wales and Northern Ireland*. CIRIA, London.

Environment Waikato. 2000. *Guidelines for Stormwater Discharge Consent Applications and Stormwater Management Plans*. Environment Waikato, Hamilton, New Zealand.

Hartwell, S., Reid, P. 2002. *Waitakere City Roading Stormwater Strategy*. Presented to *Roading and Stormwater: Technical Workshop*. Road Controlling Authorities Forum, Ministry of Transport and New Zealand Water and Wastes Association. Wellington, New Zealand. 6-7 May, 2002.

Ministry for the Environment. 2003. *A Guide to Designations under the Resource Management Act 1991*. Ministry for the Environment, Wellington, New Zealand.

Ministry of Transport. 2002. *New Zealand Transport Strategy*. Ministry of Transport, Wellington, New Zealand.

New Zealand Standards Council. 2004. *New Zealand Standard: NZS 4404:2004: Land Development and Subdivision Engineering*. Standards New Zealand, Wellington.

7. Bibliography

- New Zealand Standards Council. 2001. *New Zealand Standard: SNZ HB 44:2001: Subdivision for People and the Environment*. Standards New Zealand, Wellington.
- New Zealand Water and Wastes Association (NZWWA). 2001. *Needs Analysis and Scoping Survey for Stormwater Quality Management* [Online]. Available: <http://www.nzwwa.org.nz/eventdocs/2002/StormwaterScopingSurveyReportSep2001.pdf>
- Parliamentary Commissioner for the Environment. 2001. *Beyond Ageing Pipes – Urban Water Systems for the 21st Century*. Parliamentary Commissioner for the Environment, Wellington, New Zealand.
- Parliamentary Commissioner for the Environment. 2000. *Ageing Pipes and Murky Waters – Urban Water System Issues for the 21st Century*. Parliamentary Commissioner for the Environment, Wellington, New Zealand.
- Riggle, D. 2001. Sustainable Urban Drainage: Scotland Leads the Way. *Water and Environment Manager, February 2001*: 6-7.
- Scottish Environmental Protection Agency (SEPA). 2000. *Ponds, Pools and Lochans, Guidance on Good Practice in the Management and Creation of Small Water Bodies in Scotland*. Scottish Environmental Protection Agency, Stirling.
- Scottish Environmental Protection Agency (SEPA). 1999. *Nature's Way: A Guide to Surface Water Best Management Practices, the Effective and Economical Answer to Non-Point Source Pollution*. Scottish Environmental Protection Agency, Stirling.
- Tasman District Council. 2001. *Roading Asset Management Plan*. Tasman District Council, Richmond, New Zealand.
- Transit New Zealand. 2002. *Transit Strategic Plan*. Transit New Zealand, Wellington.
- Transit New Zealand. 2000. *State Highway Asset Management Manual*. Transit New Zealand, Wellington.
- Transit New Zealand. 1999. *National State Highway Strategy*. Transit New Zealand, Wellington.
- United States Environmental Protection Agency. 2002 (last update). *Texas Non-Point Source Book: Urban Run-off Quality Best Management Practice* [Online]. Available: <http://www.txnpsbook.org/BMPs/URBMPS.htm>
- United States Environmental Protection Agency. 1992. *Stormwater Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices*. United States Environmental Protection Agency (US EPA), Washington DC.
- Waitakere City Council. 2000. *Waitakere City Comprehensive Urban Stormwater Management Strategy and Action Plan*. Draft Report. Waitakere City Council, Waitakere City, New Zealand.
- Waitakere City Council. 1999. *Countryside and Foothills Stormwater Management Code of Practice*. Waitakere City Council, Waitakere City, New Zealand.
- Waitakere City Council. 1999. *Guidelines for Best Practice – Water Management*. Waitakere City Council, Waitakere City, New Zealand.

Wellington Regional Council. 1994. *Code of Practice for Land Development*. Wellington Regional Council, Wellington, New Zealand.

Westerman, H.L. 1998. *Cities for Tomorrow – Integrating Land Use, Transport and the Environment: Better Practice Guide*. Austroads, Haymarket, NSW.

7.3 Gaining Resource Consents for Stormwater Management

Auckland Regional Council. 2001. *Guidelines for Comprehensive Catchment Discharge Consents*. Auckland Regional Council, Auckland, New Zealand.

Environmental Defence Society. 2004 (March 17 – last update). *Resource Management Act for the Community* [Online]. EDS, New Zealand.
Available: <http://www.rmaguide.org.nz/>

Kapua, P., Williams, J., Pond, E. 1999. *Maori Consultation and Protocol*. DSL Publishing, Auckland, New Zealand.

Ministry for the Environment. 2003. *Guidelines for Consulting with Tangata Whenua under the RMA: An Update on Case Law*. Ministry for the Environment (MfE), Wellington, New Zealand.

Ministry for the Environment. 2001. *The Resource Management Act and You: Getting in on the Act*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment. 2000. *Iwi and local government interaction under the Resource Management Act 1991: Examples of good practice*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment. 2000. *Talking Constructively: A Practical Guide for Building Agreements between Iwi, Hapu and Whanau, and Local Authorities*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment. 1999. *Your Guide to the Resource Management Act*. Draft Report. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment. 1999. *A Guide to Preparing a Basic AEE*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment. 1999. *Auditing Assessments of Environmental Effects: A Good Practice Guide*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment. 1999. *Striking a Balance: A Practice Guide on Consultation and Communication for Project Advocates*. Ministry for the Environment, Wellington, New Zealand.

Parliamentary Commissioner for the Environment. 1998. *Kaitiakitanga and Local Government: Tangata Whenua Participation in Environmental Management*. Parliamentary Commissioner for the Environment, Wellington, New Zealand.

Transit New Zealand. 1994. *Planning for a Safe and Efficient State Highway Network under the Resource Management Act 1991*. Transit New Zealand, Wellington.

7.4 Environmental Effects and Mitigation Measures for Stormwater Management

Auckland Regional Council. 2002. Blueprint for Monitoring Urban Receiving Environments. *ARC Technical Publication 168*. Auckland Regional Council, Auckland, New Zealand.

Auckland Regional Council. 2000. Fish Passage Guidelines in the Auckland Region. *ARC Technical Publication 131*. Auckland Regional Council, Auckland, New Zealand.

Auckland Regional Council. 1995. The Environmental Impacts of Urban Stormwater Run-off. *ARC Technical Publication 53*. Auckland Regional Council, Auckland, New Zealand.

Auckland Regional Council. 1992. An Assessment of Stormwater Quality and the Implications for Treatment of Stormwater in the Auckland Region. *ARC Technical Publication 5*. Auckland Regional Council, Auckland, New Zealand.

Australian and New Zealand Environment & Conservation Council. 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment & Conservation Council (ANZECC), Canberra.

Australian Road Research Board (ARRB) Transport Research. 2001. *Road Run-off and Drainage: Environmental Impacts and Management Options*. Prepared for Austroads, Haymarket, NSW.

Babich, J., Lewis, G. 2001. *Contaminant Loadings in Stormwater Run-off and Wastewater Overflows: A Waitakere City Case Study*. Proceedings of Second South Pacific Stormwater Conference: *Rain – The Forgotten Resource*. Auckland, New Zealand, 27-29 June, 2001. New Zealand Water & Wastes Association, Wellington.

Barrett, M.E., Zuber, R.D., Collins, E.R., Malina, J.F., Charbeneau, P.E., Ward, G.H. 1995. *A Review and Evaluation of Literature Pertaining to the Quantity and Control of Pollution from Highway Run-off and Construction*. Center for Research in Water Resources, University of Texas, Austin, USA.

Boubee, J., Jowett, I., Nichols, S., Williams, E. 1999. *Fish Passage at Culverts: A Review with Possible Solutions for New Zealand Indigenous Species*. Prepared for NIWA and Department of Conservation, New Zealand.

Boxall, A.B.A. 1995. The characterisation and toxicity of sediment contaminated with road run-off. *Water Research* 33(10): 2043-2050.

Cawthron Institute. 2000. *Fish Passage in New Zealand Waterways* [Online]. Available: http://www.cawthron.org.nz/Assets/fish_passage.pdf

Charbeneau, R.J., Barrett, M.E. 1998. Evaluation of methods for estimating stormwater pollution loads. *Water Environment Research* 70(7): 1295-1302.

Collier, K.J., Cooper, A.B., Davies-Colley, R.J., Rutherford, J.C., Smith, C.M., Williamson, R.B. 1995. *Managing Riparian Zones: A Contribution to Protecting New Zealand's Rivers and Streams*. Department of Conservation, Wellington, New Zealand.

Driscoll, E.D., Shelley, P.E., Strecker, E.W. 1990. *Pollutant Loadings and Impacts from Highway Stormwater Run-off*. Prepared for the Federal Highway Administration, Washington DC, USA.

Hickey, C.W., Clements, W.H. 1998. Effects of heavy metals on benthic macroinvertebrate communities in New Zealand streams. *Environmental Toxicology and Chemistry* 17: 2338-2346.

Horner, R.R., May, W.M. 1999. *Regional Study supports Natural Land Cover Protection as Leading Best Management Practice for Maintaining Stream Ecological Integrity*. Pp. 233-247 in Proceedings of First South Pacific Stormwater Conference: *Comprehensive Stormwater and Aquatic Ecosystem Management*. Auckland, New Zealand, 22-26 February, 1999. New Zealand Water & Wastes Association, Wellington.

Kingett Mitchell & Associates. 2003. *Metals in Particulate Material on Road Surfaces*. Prepared for Ministry of Transport, New Zealand.

Kingett Mitchell & Associates. 2000. *Ministry of Transport Contaminants Database: Support Manual. Version 1.2*. Prepared for Ministry of Transport, New Zealand.

Kingett Mitchell & Associates. 2000. *Preliminary Examination of Organic Compounds Present in Tyres, Brake Pads, and Road Bitumen in New Zealand*. Prepared for Ministry of Transport, New Zealand.

Kingett Mitchell & Associates. 2000. *Preliminary Examination of Trace Elements Present in Tyres, Brake Pads, and Road Bitumen in New Zealand*. Prepared for Ministry of Transport, New Zealand.

Kingett Mitchell & Associates. 1999. *The Effects of Road Transport on Freshwater and Marine Ecosystems*. Prepared for Ministry of Transport, New Zealand.

Kingett Mitchell & Associates, Fuels & Energy Management Group. 2004. *Road Transport Impacts on Aquatic Ecosystems: Issues and Context for Policy Development*. Draft Final Report. Prepared for Ministry of Transport, New Zealand.

Kingett Mitchell & Associates, Fuels & Energy Management Group. 2002. *Emission Factors for Contaminants Released by Motor Vehicles in New Zealand*. Prepared for Ministry of Transport & Infrastructure, Auckland, New Zealand.

Kuschel, G. (NIWA). 2000. *Transport Effects on Aquatic Ecosystems*. Presented to Stormwater and Transport (SWAT) Workshop: *Sustainable Aquatic Habitats in Human Settlements*. 26-27 July, 2000. National Institute of Water & Atmospheric Research (NIWA), Hamilton, New Zealand.

Kuschel, G., Timperley, M. 1999. SWAT's up Doc? The effects of Stormwater and Transport on Urban Streams and Estuaries. *Water and Atmosphere* 7(3): 22-25. Reprinted in *Water & Wastes in NZ* 109: 36-39; *NZ Science Monthly* 11(2): 6-8.

Lau, S., Stenstrom, M.K. 2001. *Metals and PAH Adsorbed to Street Particles*. Proceedings of Second South Pacific Stormwater Conference: *Rain – The Forgotten Resource*. Auckland, New Zealand, 27-29 June, 2001. New Zealand Water & Wastes Association, Wellington.

Long, E.R., MacDonald, S.L., Calder, F.D. 1995. Incidence of Adverse Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. *Environmental Management* 19(1): 81-97.

McConchie, J.A. 1992. *Urban Hydrology*. Pp. 335-364 in: Mosley, M.P. (Ed.) *Waters of New Zealand*. New Zealand Hydrological Society, Wellington, New Zealand.

- Mills, G. (NIWA). 2000. *PAH in NZ Estuaries: Are they a Problem?* Presented to Stormwater and Transport (SWAT) Workshop: *Sustainable Aquatic Habitats in Human Settlements*. 26-27 July, 2000. National Institute of Water and Atmospheric Research (NIWA), Hamilton, New Zealand.
- Mills, G. (NIWA). 2000. *Reducing the Toxicity of Organic Contaminants in Urban Streams*. Presented to Stormwater and Transport (SWAT) Workshop: *Sustainable Aquatic Habitats in Human Settlements*. 26-27 July, 2000. National Institute of Water and Atmospheric Research (NIWA), Hamilton, New Zealand.
- Ministry of Transport. 1996. *Land Transport Pricing Study: Environmental Externalities*. Ministry of Transport, Wellington, New Zealand.
- National Institute of Water & Atmospheric Research (NIWA). 1999. *Broad-scale Assessment of Urban Stormwater Issues in the Waikato Region*. Prepared for Environment Waikato, Hamilton, New Zealand.
- National Institute of Water & Atmospheric Research (NIWA). 1998. *Urban Stream Habitat Assessment Method (USHA)*. Prepared for Ministry for the Environment, New Zealand.
- National Institute of Water & Atmospheric Research (NIWA). 1995. *Comparison of Run-off Quality from Roads versus other Urban Land Uses*. Prepared for Auckland Regional Council, New Zealand.
- Quinn, J.M. 2000. *Effects of Pastoral Development*. Pp. 208-229 in: *New Zealand Stream Invertebrates: Ecology and Implications for Management*. New Zealand Limnological Society, Christchurch, New Zealand.
- Ryan, P.A. 1991. Environmental Effects of Sediment in New Zealand Streams: A Review. *NZ Journal of Freshwater and Marine Research* 25: 201-221.
- Sherriff, J. 1998. An Investigation into Water Quality Effects of Transport. *WRC Publication WRC/RINV-T-98/25*. Wellington Regional Council, Wellington, New Zealand.
- Suren, A. 2000. *Effects of Urbanisation*. Pp. 260-288 in *New Zealand Stream Invertebrates: Ecology and Implications for Management*. New Zealand Limnological Society, Christchurch, New Zealand.
- Suren, A. 1998. Impact of Slip Sediment on the Biota in a New Zealand Alpine Stream. *Transfund New Zealand Research Report No. 97*. 50pp.
- Suren, A., Snelder, T., Scarsbrook, M. 1999. *Urban Stream Habitat Assessment Method: A Management Tool for Resources Managers*. Pp. 129-137 in *Proceedings of First South Pacific Stormwater Conference: Comprehensive Stormwater and Aquatic Ecosystem Management*. Auckland, New Zealand, 22-26 February, 1999. New Zealand Water & Wastes Association, Wellington.
- Timperley, M. (NIWA). 2002. *Urban Contaminants Research: Transport-Streams-Estuaries*. Presented to *Roading and Stormwater: Technical Workshop*. Road Controlling Authorities Forum, Ministry of Transport and New Zealand Water & Wastes Association, Wellington, New Zealand, 6-7 May, 2002.

Timperley, M. (NIWA). 2000. *Chemical Contamination of Urban Streams*. Presented to Stormwater and Transport (SWAT) Workshop: *Sustainable Aquatic Habitats in Human Settlements*. 26-27 July, 2000. National Institute of Water & Atmospheric Research (NIWA). Hamilton, New Zealand.

Timperley, M.H., Golding L., Webster, K.S. 2001. *Fine Particulate Matter in Urban Streams: Is it a Hazard to Aquatic Life?* Pp. 135-141 in Proceedings of Second South Pacific Stormwater Conference: *Rain – The Forgotten Resource*. Auckland, New Zealand, 27-29 June, 2001. New Zealand Water & Wastes Association, Wellington.

Transport & Environment Committee. 1998. *Inquiry into the Environmental Effects of Road Transport*. New Zealand House of Representatives, Wellington, New Zealand.

United States Environmental Protection Agency. 1996. *Indicators of Environmental Impacts of Transportation: Highway, Rail, Aviation and Maritime Transport*. United States Environmental Protection Agency (US EPA), Washington DC, USA.

Webster, K. (NIWA). 2000. *Predicting Metal Bio-Availability*. Presented to Stormwater and Transport (SWAT) Workshop: *Sustainable Aquatic Habitats in Human Settlements*. 26-27 July, 2000. National Institute of Water & Atmospheric Research (NIWA), Hamilton, New Zealand.

Williamson, R.B. (NIWA). 2000. *Predicting Contaminant Accumulation in Urban Estuaries*. Presented to Stormwater and Transport (SWAT) Workshop: *Sustainable Aquatic Habitats in Human Settlements*. 26-27 July, 2000. National Institute of Water & Atmospheric Research (NIWA). Hamilton, New Zealand.

Williamson, R.B. 1993. *Urban Run-off Data Book: A Manual for the Preliminary Evaluation of Urban Stormwater Impacts on Water Quality*. *NIWA Water Quality Centre Publication No. 20*. National Institute of Water & Atmospheric Research (NIWA), Hamilton, New Zealand.

Williamson, R.B. 1985. *Urban Stormwater Quality 1: Hillcrest*, Hamilton, New Zealand. *NZ Journal of Marine and Freshwater Research* 19(3): 413-427.

Winterbottom, J., Orton, S., Hildrew, A., Lancaster, J. 1997. *Field Experiments on Flow Refugia in Streams*. *Freshwater Biology* 37: 569-580.

Wu, J.J., Allan, C.J., Saunders, C., Evert, J.B. 1998. *Characterisation and Pollution Loading Estimation for Highway Run-off*. *Journal of Environmental Engineering*, July 1998: 584-592.

7.5 Engineering Methods for Stormwater Management

Auckland Regional Council. 2002. *Stormwater Management Devices: Design Guidelines Manual*. *ARC Technical Publication 10 (revision of 1992 draft)*. Auckland Regional Council, Auckland, New Zealand.

Auckland Regional Council. 2000. *Low Impact Design Manual for the Auckland Region*. *ARC Technical Publication 124*. Auckland Regional Council, Auckland, New Zealand.

Auckland Regional Council. 1999. *Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region*. *ARC Technical Publication 90*. Auckland Regional Council, Auckland, New Zealand.

- Auckland Regional Council. 1999. Guidelines for Stormwater Run-off Modelling in the Auckland Region. *ARC Technical Publication 108*. Auckland Regional Council, Auckland, New Zealand.
- Auckland Regional Council. 1995. Comprehensive Catchment Stormwater Treatment Pilot Study. *ARC Technical Publication 52*. Auckland Regional Council, Auckland, New Zealand.
- Australian Road Research Board (ARRB). 2000. Water Sensitive Road Design: Design Options for Improving Stormwater Quality of Road Run-off. *AARB Technical Report 100/1*, August 2000. Australian Road Research Board, Melbourne.
- Australian Road Research Board (ARRB). 1993. *Unsealed Road Manual: Guidelines to Good Practice*. Australian Road Research Board, Melbourne.
- Austroroads. 1994. *Waterway Design: A Guide to the Hydraulic Design of Bridges, Culverts and Floodways*. Austroroads, Haymarket, NSW.
- Bofinger, H., Burtayne, P.C., Marais, C.P. et al. 1990. The Design, Construction and Maintenance of Low Volume Rural Roads and Bridges in Developing Areas. *CSIR Synopsis Report S89/2*. CSIR Division of Roads and Transport, Pretoria, South Africa.
- Center for Watershed Protection. 2003 (June 16 – last update). *The Stormwater Manager's Resource Center* [Online]. Available: <http://www.stormwatercenter.net/>
- Christchurch City Council. 2003. *Waterways, Wetlands and Drainage Guide: Part B: Design*. Christchurch City Council, Christchurch, New Zealand.
- Chow, Ven Te. 1964. *Handbook of Applied Hydrology*. McGraw-Hill, New York.
- Chow, Ven Te. 1959. *Open-Channel Hydraulics*. McGraw-Hill, New York.
- Concrete Pipe Association of Australasia. 1997. *Hydraulics of Precast Concrete Conduits, Pipes and Box Culverts*. In: *Hydraulic Design Manual*. New Zealand edition. Concrete Pipe Association of Australasia (CPAA), St Leonards, Australia.
- Crunkilton, R., Kron, D. 1999. *Assessing the Effectiveness of a Pilot Scale Wet Detention Basin in Reducing Toxicity of Urban Run-off*. Proceedings of First South Pacific Stormwater Conference: *Comprehensive Stormwater and Aquatic Ecosystem Management*. Auckland, New Zealand, 22-26 February, 1999. New Zealand Water & Wastes Association, Wellington.
- Earles, T.A., Fitch G.M., Yu, L.Y. 1999. *Field Monitoring of Constructed Wetlands Receiving Highway Run-off*. Proceedings of First South Pacific Stormwater Conference: *Comprehensive Stormwater and Aquatic Ecosystem Management*. Auckland, New Zealand, 22-26 February, 1999. New Zealand Water & Wastes Association, Wellington.
- Ellis, B.J. 1999. *Vegetative Discharge Systems for Highway Discharges: Design and Operation*. Proceedings of First South Pacific Stormwater Conference: *Comprehensive Stormwater and Aquatic Ecosystem Management*. Auckland, New Zealand, 22-26 February, 1999. New Zealand Water and Wastes Association, Wellington.
- Environmental Protection Authority Victoria. 1991. *Construction Techniques for Sediment Pollution Control*. Environmental Protection Authority, Southbank, Victoria, Australia.
- French, R.H. 1985. *Open-Channel Hydraulics*. McGraw-Hill, New York.

Intergovernmental Panel on Climate Change. 2001. *Climate Change 2001: The Scientific Basis* [Online]. Available: <http://www.ipcc.ch/pub/tar/wg1/011.htm>

Kadlec, R., Knight, R. 1996. *Treatment Wetlands*. CRC Press, Lewis Publishers, London.

Land Systems EBC. 1993. *Better Drainage: Guidelines for the Multiple Use of Drainage Systems*. Prepared for New South Wales Government Department of Planning, Australia.

Larcömbe, M. 2002. *Design for Vegetated Wetlands for the Treatment of Urban Stormwater in the Auckland Region*. Auckland City Council, Auckland, New Zealand.

Leersnyder, H. 1993. *The Performance of Wet Detention Ponds for the Removal of Urban Stormwater Contaminants in the Auckland (NZ) Region*. MSc Thesis. University of Auckland, New Zealand.

Ministry of Works & Development. 1977. *Highway Surface Drainage: Design Guide for Highways with a Positive Collection System*. Ministry of Works & Development, Wellington, New Zealand.

Ministry of Works & Development. 1980. *A Method for Estimating Design Peak Discharge. MWD Technical Memorandum No. 61*. Ministry of Works & Development, Wellington, New Zealand.

Montgomery Watson NZ Ltd. 1999. *Environmental Management for Roding Contractors. I. Overview and Case Study. Transfund New Zealand Research Report No. 130*. 40pp.

Montgomery Watson NZ Ltd. 1999. *Environmental Management for Roding Contractors. II. Provisional Guidelines for Erosion and Sediment Management during Road Works. Transfund New Zealand Research Report No. 131*. 34pp.

Montgomery Watson NZ Ltd. 1999. *Environmental Management for Roding Contractors. III. Provisional Guidelines for Environmental Management during Road Works. Transfund New Zealand Research Report No. 132*. 26pp.

National Institute of Water & Atmospheric Research (NIWA). 1998 (May 26 – last update). *Climate Variability and Change: Assessing likely Regional Impacts of Climate Change* [Online]. Available: <http://www.niwa.co.nz/rc/atmos/clivar/impacts>

National Institute of Water & Atmospheric Research (NIWA). 1998. *Significant Shift in New Zealand Climate*. Media Release – 6 August 1999 [Online]. Available: <http://www.niwa.co.nz/pubs/mr/archive/1998-08-06-1>

New South Wales Environmental Protection Authority. 1997. *Managing Urban Stormwater: Treatment Techniques*. Draft Report. Environmental Protection Authority, Chatswood, NSW, Australia.

New Zealand Building Authority. 2000. *Approved Document B1: Structure*. In: *The New Zealand Building Code Handbook and Approved Documents*. New Zealand Building Authority, Wellington.

New Zealand Building Authority. 2000. *Approved Document E1: Surface Water*. In: *The New Zealand Building Code Handbook and Approved Documents*. New Zealand Building Authority, Wellington.

New Zealand Institute of Engineers. 1980. *A Guideline and Procedure for Hydrological Design of Urban Stormwater Systems*. New Zealand Institute of Engineers, Wellington.

O'Riley, A., Pandey, S., Langdon, A., Wilkins, A. 2002. Characterisation of Road Run-off Contaminants from New Zealand Roads. *Transfund New Zealand Research Report No. 228*. 119pp.

Pandey, S., Taylor, M., Lee, R., Shaver, E. 2004. *Reducing Road Run-off Contaminants through Low-Cost Treatment Wall (Filter) Systems*. Prepared for Landcare Research, Hamilton, New Zealand.

Payne Royds. 2000. *Preliminary Investigation of Drainage Easements in the Wellington Region*. Prepared for Transit New Zealand, Wellington.

Pratt, C.J. 2004 (February – last update). *Sustainable Drainage: A Review of Published Material on the Performance of Various SUDS Components* [Online]. Available: http://www.ciria.org.uk/suds/pdf/suds_lit_review_04.pdf

Singhal, N. 2000. Capturing stormwater sediment. *Transearch* 39: 5.

Singhal, N., Gunasekera, H.D. 1999. Field evaluation of catchbasin insert performance. *Transfund New Zealand Research Report No. 152*. 37pp.

Transfund New Zealand. 2001. *Case Study and Assessment of Environmental Effects – Sediment Control during Roading Construction*. Transfund New Zealand, Wellington.

Transit New Zealand. 2000. *Draft State Highway Geometric Design Manual*. Transit New Zealand, Wellington.

Transit New Zealand. 2000. Specification for Pipe Subsoil Drain Construction. *TNZ F/2 specification*. Transit New Zealand, Wellington.

Transit New Zealand. 1999. *State Highway Control Manual (SM012)*. Issue 3, 1999. Transit New Zealand, Wellington.

Transit New Zealand. 1994. *Bridge Manual: Design and Evaluation*. First edition. Transit New Zealand, Wellington.

United Kingdom Department of the Environment. 1977. Hydraulic Design of Pipes. *UK DoE Hydraulics Research Paper No. 4: Tables (metric edition)*. United Kingdom Department of the Environment, London.

Urban Water Resources Research Council. 2003 (September 8 – last update). *International Stormwater Best Management Practices (BMP) Database* [Online]. Available: <http://www.bmpdatabase.org/>

Vennard, J.K., Street, R.L. 1982. *Elementary Fluid Mechanics* (6th ed.). John Wiley & Sons, Indianapolis, USA.

Viessman, W., Lewis, G.L. 1996. *Introduction to Hydrology* (4th ed.). Addison-Wesley, Boston, USA.

Wellington Regional Council. 2002. *Erosion and Sediment Control Guidelines for the Wellington Region*. Wellington Regional Council, Wellington, New Zealand.

Wong, T., Breen, P., Lloyd, S. 2000. *Water Sensitive Road Design – Design Options for Improving Stormwater Quality of Road Run-off*. Corporate Research Centre for Catchment Hydrology, Clayton, Australia.

Wong, T., Breen, P., Somes, N., Lloyd, S. 1998. Managing Urban Stormwater using Constructed Wetlands. *Industry Report 98/7*. Cooperative Research Centre for Catchment Hydrology, Clayton, Australia.

Zanders, J., Taylor, M., McLeod, M., Simcock, R., Robinson, B. 2004. *“Raingardens” for Treating Stormwater*. Prepared for Landcare Research, New Zealand.

7.6 Relevant Conferences and Workshops

National Institute of Water and Atmospheric Research (NIWA). 2000. Stormwater and Transport (SWAT) Workshop: *Sustainable Aquatic Habitats in Human Settlements*. NIWA, Hamilton, New Zealand, 26-27 July, 2000.

New Zealand Water & Wastes Association (NZWWA). 2003. Third South Pacific Conference on Stormwater and Aquatic Resource Protection combined with Tenth Annual Conference of the Australasian Chapter of the International Erosion Control Association: *Communication and Linkages for Aquatic Resource Protection*. Auckland, New Zealand, 14-16 May, 2003. New Zealand Water & Wastes Association, Wellington.

New Zealand Water & Wastes Association. 2002. New Zealand Water & Wastes Association Annual Conference and Expo. Christchurch, New Zealand, 25-27 September, 2002.

New Zealand Water & Wastes Association. 2001. Second South Pacific Stormwater Conference: *Rain – The Forgotten Resource*. Auckland, New Zealand, 27-29 June, 2001. New Zealand Water & Wastes Association, Wellington.

New Zealand Water & Wastes Association. 2000. Water 2000 Conference: *Guarding the Global Resource*. Auckland, New Zealand, March, 2000.

New Zealand Water & Wastes Association. 1999. First South Pacific Stormwater Conference: *Comprehensive Stormwater and Aquatic Ecosystem Management*. Auckland, New Zealand, 22-26 February, 1999. New Zealand Water & Wastes Association, Wellington.

Road Controlling Authorities Forum, Ministry of Transport and New Zealand Water & Wastes Association. 2002. *Roading and Stormwater: Technical Workshop*. Wellington, New Zealand, 6-7 May, 2002.

United States Environmental Protection Agency. 1993. National Conference on Urban Run-off Management: *Enhancing Urban Watershed Management at the Local, County and State Levels*. Chicago, USA, 30 March-2 April, 1993. United States Environmental Protection Agency, Washington.

Waitakere City Council. 2000. *Stormwater Strategy Workshop*. Waitakere City Council, Waitakere City, Auckland, New Zealand, 6 October, 2000.