Pittwater Council

WARRIEWOOD VALLEY URBAN LAND RELEASE

WATER MANAGEMENT SPECIFICATION

Revised Version

February 2001

Adopted by Pittwater Council on 12 February 2001

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REPORT STATUS

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1	May, 1999	Final	NIC	NVL	NIC
2	June, 2000	Draft	LCH	NVL	NVL
3	July, 2000	Final Draft	LCH	NVL	NVL
4	August, 2000	Draft for Exhibition	LCH	NVL	NVL
5	February, 2001	Final	LCH	NVL	NVL

It is the responsibility of the reader to verify the currency of the version number of this report.

FOREWORD

This document has been prepared to ensure that the development of the Warriewood Valley is carried out in an ecologically sustainable manner within the realm of the water environment. The document aims to achieve this by providing Applicants and Council with tools to guide the Applicants preparation of water-related documentation in the Rezoning, Development Application, Construction Certificate, Subdivision Certificate and Handover phases for the redevelopment (on a sector by sector basis) of the Valley.

This document provides specific requirements for the preparation by Applicants of Rezoning Applications, Development Applications, Construction Certificates, Subdivision Certificates and Handover documentation and outlines what levels of expertise will be required for certification to meet the requirements of the Warriewood Valley Development Control Plan (DCP No 20, 1998).

The document is to be read in conjunction with:

- Warriewood Valley Landscape Masterplan and Design Guidelines (2000)
- Warriewood Valley Section 94 Contributions Plan
- Warriewood Valley Concept Masterplan (2000)
- Warriewood Valley Urban Land Release Planning Framework (1999)
- Warriewood Valley Development Control Plan No 20 (1998)
- Development Control Plan No 23 Landscape and Vegetation Management
- Warriewood Valley Roads Masterplan (1999)
- Pittwater Local Environment Plan (Amendment No 36)
- Reference to various documents listed as appropriate reference materials for various components of water management.

This revised version of the document (Version 5) follows on from the first release of the Warriewood Valley Water Management Specification (May, 1999, Version 1) and aims to include the findings of additional investigations undertaken by Council and to incorporate developments in water management practice.

Prior to adoption by Council, the first release (May, 1999, Version 1) document was issued to all members of the Warriewood Land Release Committee and publicly exhibited. Submissions were received from various stakeholders including:

- NSW Environment Protection Authority
- NSW Roads and Traffic Authority
- Sydney Water Corporation
- Warriewood Valley Rezoning Association Incorporated
- Patterson Britton and Partners Pty Ltd - Consulting Engineers
- Gutteridge Haskins and Davey Pty Ltd- Consulting Engineers

The draft of this second release (August, 2000, Version 4) document was issued to all members of the Warriewood Land Release Committee and publicly exhibited prior

to adoption by Council. In addition to comments from various divisions within Council (including Urban Infrastructure, Planning and Natural Resources), written submissions were received from various stakeholders including:

- Department of Land and Water Conservation
- Byrne and Associates Pty Ltd
- Gutteridge Haskins and Davey Pty Ltd
- Don Fox Planning Pty Ltd.

The document has subsequently been revised as a result of these comments.

This revised document has been prepared by Lawson & Treloar Pty Ltd for Pittwater Council and independently reviewed by WBM Oceanics Australia. Landscape figures for the document were prepared by Environmental Partnership Pty Ltd.

EXECUTIVE SUMMARY

Pittwater Council has a duty of care in the management of waterways within the local government area along with other natural resource stakeholders including the Department of Land and Water Conservation, NSW Fisheries and the NSW Environment Protection Authority. To fulfil and surpass this duty, Council has commissioned the preparation of this water management specification to manage the water aspects of the development by various Applicants of sectors of the Warriewood Valley. The specification is based on current best management practice and present regulatory codes and guidelines and encourages the use of innovative techniques in the field of water management.

This water management specification aims to set benchmarks and provide practical guidance for Applicants and Council for the management of water during and after the development of lands on a sector by sector basis within the Warriewood Valley. It also encourages sustainable uses of water and appropriate design of subdivisions under the banner of 'water sensitive urban design'.

The specification covers the following aspects of water management within a total catchment management approach:

- Water cycle management - maintaining and enhancing the balance of water
- Water quality management - considering the current quality of the flow in terms of pollutant concentrations and loads and ensuring the development process only enhances the waterways by reducing concentrations and loads to acceptable levels for healthy ecosystem functioning
- Watercourse and corridor management - seizing the opportunity to preserve, rehabilitate or remediate waterways and the associated corridor
- Floodplain management - providing an appropriate channel area to convey large floods without endangering life or property within the context of the watercourse and corridor management.

The specification provides guidance for the submission of documentation at the following stages of sector development:

- Rezoning Applications
- Development Applications
- Construction Certificates for Subdivision
- Subdivision Certificates
- Handover of Infrastructure to Council.

Each stage requires particular levels of detail for Applicants to complete and to be included in the reports to be submitted with applications. Guidance on this level of detail is provided in the Specification.

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GLOSSARY

Annual Exceedence Probability (AEP)	refers to the probability or risk of an event (e.g. a flood) of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded; it would occur quite often and would be relatively small. A 1%AEP flood has a low probability of occurrence of being exceeded; it would be rare but it would be relatively large.
ANZECC Guidelines	Australian and New Zealand standards and parameters of water quality for protection of ecosystems and other aquatic environments.
Australian Height Datum (AHD)	a common national plane of level corresponding approximately to mean sea level.
Bankfull Flow	volume of flow contained within the banks of a watercourse, usually up to the 1 in 2 year flow
Calibration	the process by which the results of a computer model are brought to agreement with observed data.
Catchment	the area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Cross-section	a description of the shape of the river channel in a direction perpendicular to the direction of water flow.
Detention	detention systems have the effect of storing runoff and releasing it at a rate no greater than the pre-development peak discharge.
Development	the erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	the rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow which is a measure of how fast the water is moving rather than how much is moving.
Exceedence	the percentage of time that a flow, level or velocity is exceeded in the period of analysis.

EMC	Event-Mean Concentration. The average concentration over a period of time. It is determined by measuring the concentration and flowrate of a particular chemical in a stream or creek, and then dividing the total load by the volume of water. It can then be used to evaluate long-term pollutant loads from a catchment.
EMP	Environmental Management Plan
Flood	relatively high stream flow which overtops the natural or artificial banks in any part of a stream or river.
Floodplain	the portion of a river valley, adjacent to the river channel, which is covered with water when the river overflows during floods.
Fluvial	of or found in rivers
Handover	transfer of relevant infrastructure to Council following completion of the maintenance period being 6 months after the issue of the Subdivision Certificate or, where an MPB agreement has been reached, completion of the agreed MPB maintenance period, whichever is the latest
Hydraulics	the term given to the study of water flow in a river, in particular, the evaluation of flow parameters such as stage and velocity.
Hydraulic computer model	a numerical computer-based program which solves the equations of motion of water in rivers and streams. Topographical details are input to describe the shape and slope of the river. The model uses inflow hydrographs to provide the flows, and produces water levels, flows, wetted perimeters and water velocities within the model area.
Hydrograph	a graph that shows how the discharge changes with time at any particular location.
Hydrology	the term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Long-term	with respect to water quality, long-term is defined as the period after control measures are introduced for all pollutant sources in the valley.

Mathematical/ Computer models	the mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff and stream flow.
Medium-term	with respect to water quality, medium-term refers to the period of one year after completion of all water quality controls associated with the fully developed sector. Due to the likely fragmented nature of development, permanent water quality controls may not be fully functional for some years.
MPB	Material Public Benefit - Under the Section 94 plan a Material Public Benefit is a contribution offered by the Applicant that must consist of some physical (material) component other than the dedication of land or the payment of a monetary contribution - works in kind is a type of MPB
NATA	National Association of Testing Authorities
NPER	National Professional Engineers Register of the Institution of Engineers, Australia
On-site detention (OSD)	On-site detention refers to all types of detention of additional flow volume generated as a result of development
Overbank flow	flow that results in the water level within a watercourse exceeding the lower banks and flowing within the wider channel area, usually flows greater than a 1 in 2 year flow.
Peak discharge	the maximum discharge occurring during a flood event.
Probable maximum flood	the flood calculated to be the maximum that is likely to occur.
Probability	a statistical measure of the expected frequency or occurrence of an event (e.g. a flood). For a fuller explanation see Annual Exceedence Probability.
Rainfall-runoff model	a computer model which converts rainfall information to runoff. The models are usually empirically-based, and require calibration of model parameters to recorded series of rainfall and corresponding runoff.

Retention	retention systems have the effect of retaining runoff on-site generally for reuse or infiltration (e.g. rainwater tanks).
Riparian	the zone associated with creeks and rivers on the banks adjacent to those waterways
Runoff	the amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Short-term	with respect to water quality, short-term refers to the period during and just after development (up to 'Handover').
SQID	Stormwater Quality Improvement Device
Tributary	catchment, stream or river which flows into a larger river, lake or water body
Velocity	the speed of the water
Water Management Report	a single report submitted to accompany each application outlining the means by which the sector will meet the requirements of this Water Management Specification
Wetted perimeter	the length of water-bed interface of the cross-section which is under water

1. INTRODUCTION

1.1. BACKGROUND

Approximately 110 hectares of land in the Warriewood Valley area within the Pittwater Council area was approved for release by the Minister for Urban Affairs and Planning in 1997. When fully developed, the Urban Land Release is expected to provide approximately 1500 dwellings and 54 ha of commercial and industrial land. The area for development has been broken into 19 Sectors (Figure 1) for the purposes of managing the process, with overall Valley Masterplans for landscaping, roads and traffic.

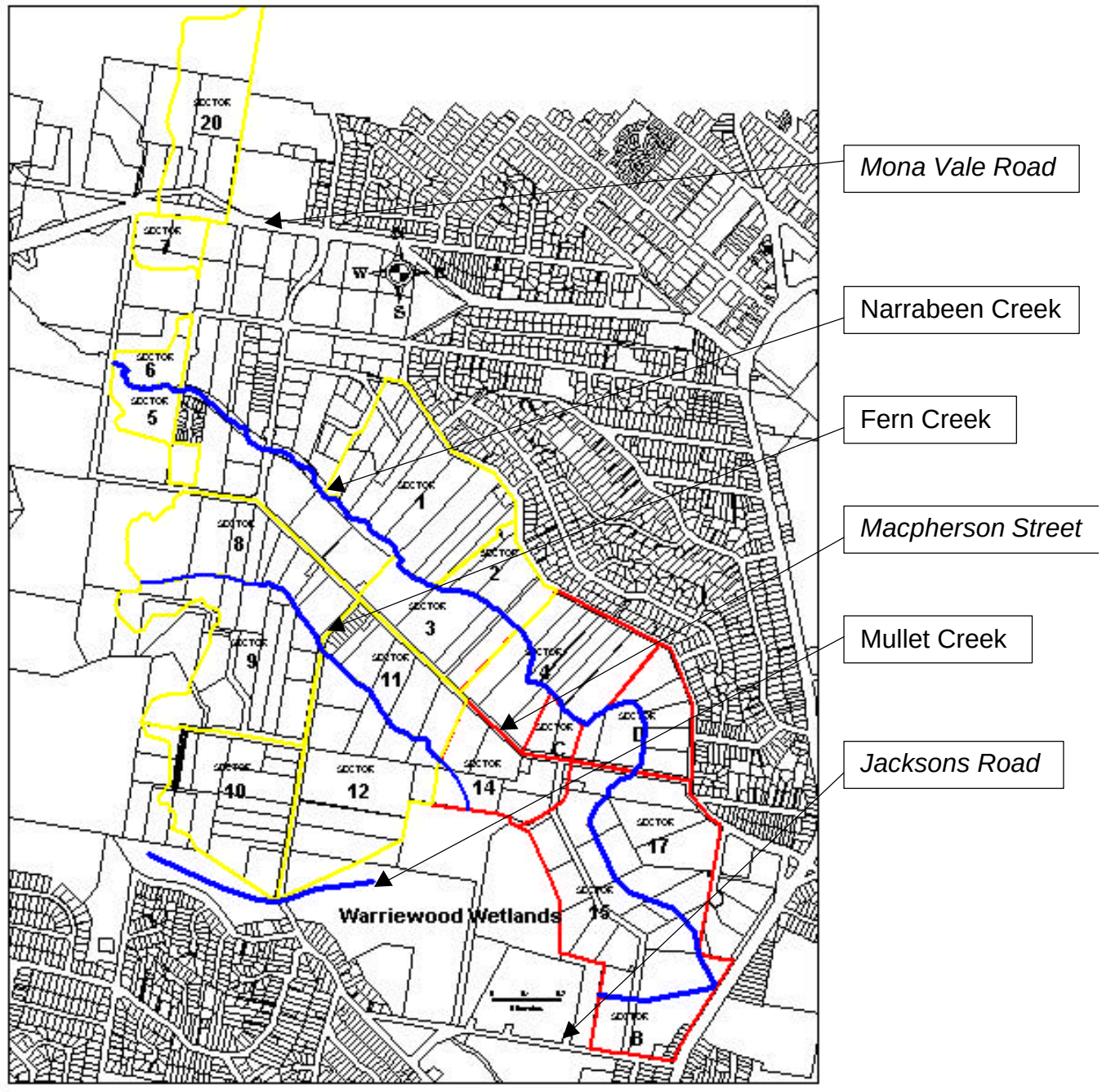
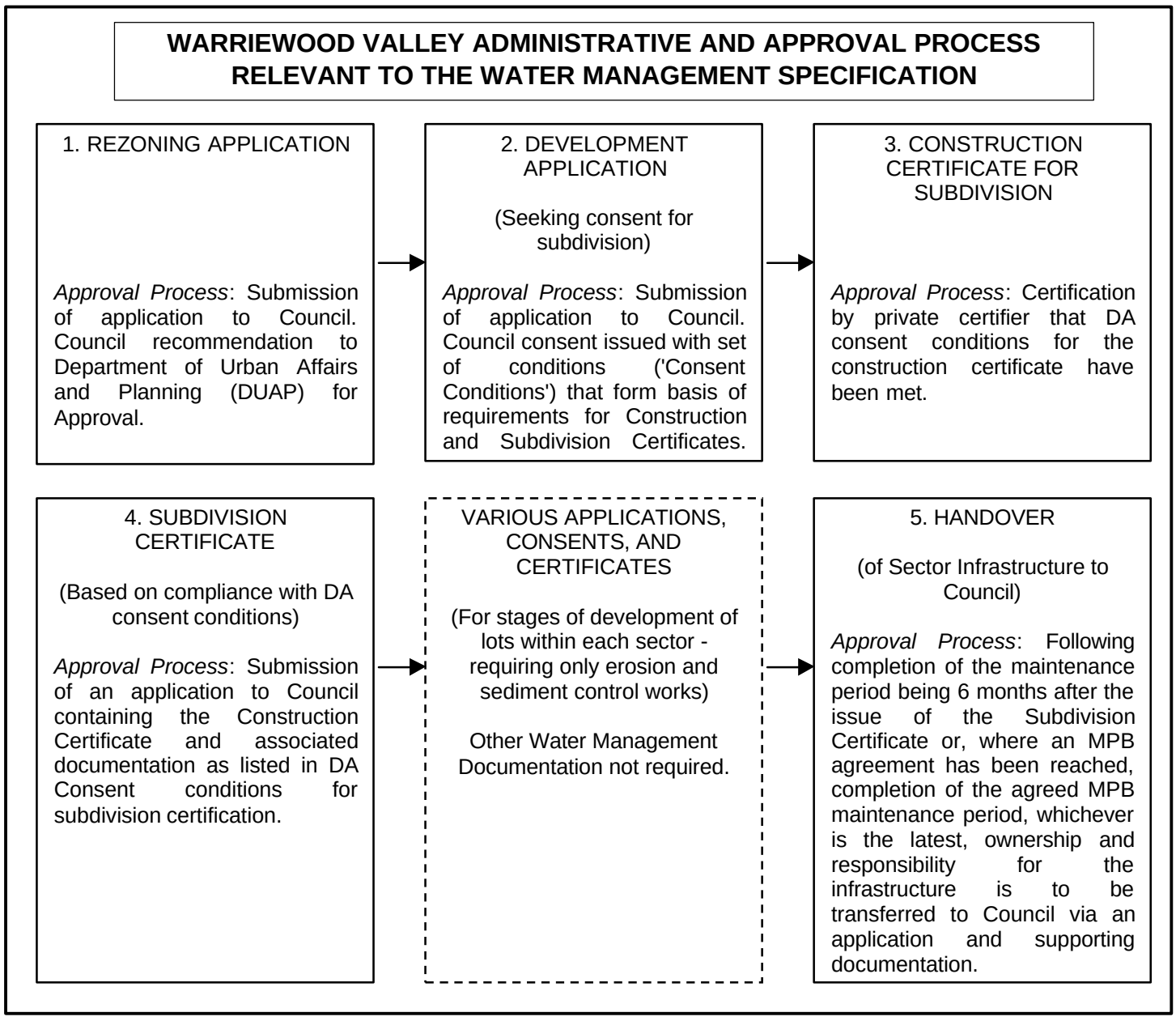


Figure 1 Sector Plan and Creeks of the Warriewood Valley - Existing Cadastre

The process of development of each sector is essentially five administrative and approval stages:

1. Rezoning Application
2. Development Application for Subdivision
3. Construction Certification for Subdivision
4. Subdivision Certificate Application
5. Handover.

Relevant stages of the development process are shown in the flowchart below.



Various documents are required for submission by Applicants for each sector at each approval stage including (but not limited to):

- Water Management Report (excluding the details of the provision of water supply and sewerage)
- Flora and fauna conservation studies
- Land contamination studies
- Aboriginal archaeology studies
- Heritage assessments, and
- Traffic and transport studies.

Details of the requirements for the Water Management Reports are the focus of this Water Management Specification.

To date, Pittwater Council has adopted an Integrated Water Management Strategy – Warriewood Valley (1997) which sets out the broad principles for the protection, restoration and maintenance of the chemical, physical and biological integrity of waterways within the release area, including Narrabeen Creek, Fern Creek and Mullet Creek and their associated receiving waters including the Warriewood Wetlands and Narrabeen Lagoon.

This Water Management Specification supersedes the Strategy with some aspects of the Strategy having been reassessed following further research and technological developments.

1.2. PURPOSE

This document provides specific requirements for supporting documentation to be prepared by Applicants in their preparation of Rezoning applications, development applications, Construction Certificates, Subdivision Certificates and Handover documentation and outlines what levels of expertise will be required for certification to meet the requirements of the Warriewood Valley Development Control Plan (DCP No 20, 1998).

1.3. CONTEXT

The document is to be read in conjunction with:

- Warriewood Valley Landscape Masterplan and Design Guidelines (2000)
- Warriewood Valley Section 94 Contributions Plan
- Warriewood Valley Concept Masterplan (2000)
- Warriewood Valley Urban Land Release Planning Framework (1999)
- Warriewood Valley Development Control Plan No 20 (1998)
- Development Control Plan No 23 Landscape and Vegetation Management
- Warriewood Valley Roads Masterplan (1999)
- Pittwater Local Environment Plan (Amendment No 36).

Reference is to also be made to the various guidelines and standards listed throughout this document.

1.4. IMPACTS OF UNCHECKED DEVELOPMENT

The present catchment is essentially semi-rural and bushland, with a number of nurseries and low-intensity commercial enterprises.

Urbanisation of the catchment will result in the creation of large areas of impervious surfaces (e.g. roads, driveways, roofs), which will typically occupy 50% of the residential catchment, and higher proportions of higher-density urban, industrial or commercial areas. The clearing of vegetation will reduce transpiration losses, further altering the water balance towards increased volumes and faster delivery of runoff to the receiving waters of Mullet Creek, Narrabeen Creek and Fern Creek (Figure 1). The majority of the runoff from an urban catchment occurs from the hard or 'impervious' areas, particularly for frequent storm events, and this Specification requires a mixture of storage and infiltration approaches to control these increases in runoff.

The increased flows, runoff volumes and sediment loads following urbanisation and the removal of riparian vegetation have significant potential to alter the form of the Mullet Creek, Fern Creek and Narrabeen Creek channels. Note that Mullet Creek lies on the south-western boundary of the land release area and will generally not be affected to the same degree as Fern Creek and Narrabeen Creek which both lie within the centre of the land release area. Unless detention or retention measures are implemented as part of the development, the cross-sectional area of the channels is likely to increase significantly through bed and bank erosion. This will essentially be due to the increased frequency of occurrence of 'bankfull' flows, which influence the channel morphology and occur much more frequently than 'overbank' floods. The overall management focus is on the stream systems and their stability and ecological values. Note that there are a number of ecologically significant locations within the Valley including a stand of Swamp Mahogany (*Eucalyptus Robusta*) adjacent to Narrabeen Creek in Sectors 4 and D as well as the Warriewood Wetlands, which form the receiving waters for flows from Sectors 8, 9, 10, 11 and 12 before flow drains to Narrabeen Lagoon. It is the responsibility of any Applicant to assess whether there are any other ecologically significant or threatened or endangered species within each sector.

Urbanisation generally increases pollutant concentrations and water temperatures in streams, with the increased runoff volumes contributing to the overall elevation of total pollutant loads. The greatest increase in pollutant loads generally occurs for frequent storm events, due to the more significant increase in runoff volumes under these conditions.

Urban runoff can also encourage the growth of weeds in urban bushland. Nutrients can be transported with stormwater via overland flowpaths into bushland. The excess nutrients encourage weed growth, as native vegetation generally requires low nutrient concentrations. Weed seeds can also be transported from residential areas by stormwater and the higher moisture content at stormwater outlets can encourage weed establishment.

1.5. STRUCTURE

This document has been structured as follows:

- An overview of the principles of water sensitive urban design (Section 2)
- A summary of the requirements for Applicants (Section 3)
- Details of the requirements for the Water Management Reports (Section 4)
- An overview of the private certification requirements (Section 5)
- An extensive list of legislation and references that provide further details that may assist in the preparation of Water Management Reports (Sections 6 and 7).

2. WATER SENSITIVE URBAN DESIGN

Wetlands, creeks and lakes are a significant resource for multiple purposes including biodiversity, recreation and tourism within the local community. Consequently stormwater management systems must be efficient from a water management viewpoint and they must also have minimum impact on the ecological and social values of the area. It is therefore essential that any water management system be ecologically based and consistent with sound engineering practice. The aim is to create an effective but unobtrusive stormwater management system that enhances, rather than reduces the values of the area and ensures minimal impact on downstream sites.

This Water Management Specification has been developed with a view to initially protecting existing water quality conditions. There is to be at least no degradation in existing water quality and habitat values as development proceeds, followed by a movement towards a long-term objective of progressive improvement in water quality and habitat restoration. Emphasis is placed on sector-based controls rather than large-scale treatment and control measures, as this approach is deemed more readily applicable to the area given the anticipated patterns of development.

The approach emphasises the ecological importance of each landscape component and sets out a strategy to present engineering approaches and where relevant structures that are compatible with, and enhance, the environment.

The strategy sets out a process that facilitates future development within the study area and sets criteria and requirements for each discrete sector for water quality and quantity and environmental constraints. Similarly, Council seeks applications, which also express a co-ordinated approach at each stage of the development process (Rezoning, development application, Construction Certificate, Subdivision Certificate and Handover).

Details of the requirements to ensure that such “water sensitive” urban design is achieved are outlined in this document and form the requirements for different application stages.

3. REQUIREMENTS FOR APPLICATIONS

Council has identified that a single Water Management Report must be provided by Applicants at each stage of the process shown in Section 1.1. Status reports during the construction period are also required. This Specification sets out the components required for each of the reports, provides advice on the content and methodology suitable for producing each report and the level of professional expertise required for each of the components (Chapter 4), including the levels of expertise which will be required for the issuing of Construction Certificates (where private certification is required) (Chapter 5).

3.1. PRE-LODGEMENT MEETINGS

Prior to submitting any documentation for Rezoning, it is recommended that Applicants seek to hold pre-lodgement meetings with both Council and the Department of Land and Water Conservation to discuss water management issues. This is particularly relevant to any sector-specific issues where this Specification may require clarification. It is recommended that these meetings be attended by both the Applicant and their water management consultants.

3.2. STAGES FOR WHICH DOCUMENTATION IS REQUIRED

There are several stages of approvals, which must be completed, for a development to be constructed and final approvals achieved. The flow chart presented in Section 1.1 outlines this process. This Specification details which Water Management Reports must be submitted to Council (or the private certifier in the case of Construction Certificates for Subdivision) at each stage of sector development i.e.:

- Rezoning Applications
- Development Applications
- Construction Certificates for Subdivision
- Subdivision Certificates
- Handover of Infrastructure to Council.

Note that between the commencement of construction up to 'Handover', status reports are required for the site, on a three monthly basis. Details are outlined in Section 3.4 and Table 3.2.

3.3. REPORTING - APPLICATIONS

The Water Management Report submitted with an application must address the overall concept of water quality management, flood protection and water cycle management in an integrated sense.

The requirements of each document required are detailed in the following sections and summarised in Table 3.1. Appendix D contains a detailed checklist of all items contained in Table 3.1. A completed sheet from Appendix D is to accompany the Water Management Report at each stage of approval.

In general, each report should be an updated version of the previous report, commenting on any additional information collected or constraints identified and resulting variations in the designs of the various components of the water management system for the site supporting the concept upon which the Rezoning Consent was granted. Any predictive models developed as part of earlier stage applications for the sector are to be recalibrated and all results checked and the outcomes revised to reflect any new data. Each of the proposed water quality and quantity management measures are to be reviewed in light of the additional information, and any conclusions modified as necessary.

A full set of the updated Water Management Report documentation is also to be submitted to Council at the Subdivision Certificate and Handover stage.

3.4. REPORTING - CONSTRUCTION COMMENCEMENT TO HANDOVER

Construction and Operational Phase Management Reports are to be submitted to Council or their nominated representative at three-monthly intervals from the commencement of construction and until Handover.

They are to contain:

- Details of rainfall for the month.
- A summary of works completed, including stormwater quality improvement devices.
- A certified site managers report, which specifically addresses each and every item of the aspects of the Environmental Management Plan (EMP) that deal with Water Quality.
- Full details of water quality sampling and test results. Note that results must be submitted to Council or Council's nominated representative within three weeks of the sampling date (Section 4.2.1 has further details).
- A section reviewing the effectiveness of the EMP.
- A certification of the report by a suitably qualified and experienced NPER professional engineer.

Table 3.1 Summary of Water Management Report Requirements

Section	Item	Stage				
		Rezoning Application	Development Application	Construction Certificate	Subdivision Certificate	Handover
4.1	Water Cycle Assessment - Water Balance Modelling Pre & Post Development		++++++++++++			
4.1.1	Stream Gauging, infiltration testing and use of local rainfall data for modelling	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦			
4.2.1	Water Quality Monitoring Plan (including at least three sites shown on plan)	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦
4.2.1, 2, C	Water Quality Monitoring Data	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data from SQID's				♦♦♦♦♦♦♦♦	♦♦♦♦♦♦
4.3	Water Quality Management Assessment - Load Modelling Pre and Post Development		++++++++++++			
4.3.1, 3	Justification of assumptions for Event Mean Concentrations	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦			
4.3.2	Identification of and details for Stormwater quality facilities			++++++++++++		
4.3.2, 4.4.5	Mosquito Risk Assessment for both Watercourse and Water Quality/Quantity features		♦♦♦♦♦♦♦♦♦♦♦	++++++++++++	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦
4.3.6, 4.6.5	Inspection and Cleaning Reports for SQID's and OSD					♦♦♦♦♦♦
4.3.6	Management Plan for Stormwater Quality Improvement Devices		♦♦♦♦♦♦♦♦♦♦♦	++++++++++++	♦♦♦♦♦♦♦♦	♦♦♦♦♦♦
4.3.5	Environmental Management Plan (Soil and Water Aspects)			++++++++++++	♦♦♦♦♦♦♦♦	
4.3.4	Erosion and Sediment Control Plan			++++++++++++	♦♦♦♦♦♦♦♦	
4.4.3, 4, 5	Existing and Proposed Creek Corridor in plan with cross/long sections with flood levels		♦♦Note 1♦♦	+++Note 1+++	Note 1	
4.4.4	Proposed Creek Corridor Planting Schedule		Note 1	++++Note 1+++	Note 1	
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan		Note 1	♦♦♦Note 1♦♦	♦♦Note 1♦♦	♦Note 1♦
4.4.5	Vegetation and Creek Maintenance and Monitoring Reports					♦Note 1♦
4.5	Flood Analysis - existing and design conditions		++++++++++++	♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦	
4.5.2	Compliance of structures and creek corridor with flood planning levels			++++++++++++		
4.5.4	Details of Interim Flood Protection Works			++++++++++++		♦♦♦♦♦♦
4.6.3	Design Storm Hydrological Modelling of Site - Pre and Post Development		++++++++++++	♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦	
4.6.3	On-Site Detention Facilities			++++++++++++		
4.6.4	Stormwater Retention Facilities			++++++++++++		
4.7	Stormwater Concept Drainage Plan		♦♦♦♦♦♦♦♦♦♦♦			

KEY:

	Preliminary Calculations/Assessment Required		*Work as Executed Plans*
	Concept Design Required	♦♦♦♦♦♦	*Required/Reviewed/Updated*
++++++++	*Detailed Assessment/Calculations/Design*		*Not required*

Note 1 Even if the works are not to be constructed by the Applicant on the land to be transferred to Council under the Material Public Benefit Option in the Section 94 Plan, preliminary investigation for Rezoning and concept design at DA stage is required

Table 3.2 Summary of Requirements for Regular Construction Period to Handover Reports

Section	Item	Stage/Timing	
		Construction Commencement to Subdivision Certificate	Subdivision Certificate to Handover
3.4, 4.2.1	Submission of water or sediment quality sampling data (wet weather or dry weather) to Council/Council's representative - three weeks after sampling once DA approval obtained	♦♦♦♦♦♦♦♦♦♦♦♦	♦♦♦♦♦♦♦♦♦♦♦♦♦
3.4	Submission of three monthly report to Council/Council's representative	♦♦♦♦♦♦♦♦♦♦♦♦	
3.4	Submission of three monthly report to Council (See also Table 3.1 - Inspection and Cleaning Reports for SQID's and OSD, Vegetation and Creek Maintenance and Monitoring Reports)		♦♦♦♦♦♦♦♦♦♦♦♦♦

♦♦♦♦♦♦♦	*Required/Reviewed/Updated*
	Not required

4. WATER MANAGEMENT REPORTS

A Water Management Report is to be submitted by the Applicant for each stage of the development and prepared by suitably qualified professionals (as outlined below).

The report is to address a number of issues related to both stormwater and water quality management within the proposed development area in various levels of detail prescribed in Table 3.1. Generally, each report must contain sections dealing with water management as follows:

- Water Cycle Assessment (Section 4.1)
- Water Quality Assessment (Section 4.2)
- Water Quality Management (Section 4.3)
- Watercourse and Corridor Preservation/Restoration (Section 4.4)
- Flood Protection (Section 4.5)
- Stormwater Quantity Management (Section 4.6)
- Stormwater Drainage Concept Plan (Section 4.7).

The professional requirements for the completion of the various aspects of the report are:

Task	**Qualifications**
Water Cycle Assessment	The assessment is to be undertaken by an experienced engineering hydrologist who is listed as an NPER member of the Institution of Engineers, Australia.
Water Quality Assessment and Monitoring	The water quality monitoring plan and all water samples to be collected are to be prepared and assessed by an experienced and qualified water quality professional with demonstrated experience in design and implementation of water quality monitoring plans using a NATA registered laboratory for sample analysis.
Water Quality Management	Water quality control facilities are to be designed by person(s) with appropriate experience and expertise in Environmental Science, Hydrology and Hydraulics and must be listed as NPER member(s) of the Institution of Engineers, Australia.
Watercourse and Corridor Preservation/ Restoration	Creek rehabilitation works are to be designed by experienced persons with appropriate expertise in Environmental Science, Hydrology and Hydraulics and must be listed as NPER members of the Institution of Engineers, Australia in conjunction with associated terrestrial and aquatic planting experts.
Flood Protection	The assessment is to be undertaken by an experienced flood hydraulics engineer who is listed as an NPER member of the Institution of Engineers, Australia.
Stormwater Quantity Management	The assessment is to be prepared by an experienced and qualified engineering hydrologist with demonstrated expertise in urban stormwater quantity management, and who is listed as an NPER member of the Institution of Engineers, Australia. Formal detention basins and onsite detention systems are also to be designed by an NPER Engineer with appropriate experience and expertise in Hydrology and Hydraulics.
Stormwater Drainage Concept Plan	The plan is to be prepared by an experienced engineer who is listed as an NPER member of the Institution of Engineers, Australia.

4.1. WATER CYCLE ASSESSMENT

A water cycle assessment is to be prepared detailing the water balance modelling for the existing (pre-developed) and post developed conditions. Details of this assessment are to be included as a chapter of the Water Management Report.

4.1.1. Establishment of Existing Conditions

Overview

An assessment is to be made of the water cycle of the existing environment, taking into account the specific soil and groundwater conditions of the site based on samples collected and analysed from the development site. The water balance is to be estimated on a daily basis using available data. The development area is to be classified according to soil types, vegetation and subsurface geology in order to predict volumes on an annual basis of overland flow, baseflow and changes in subsurface water levels. The predicted response of the area to seasonal variations in rainfall and evaporation must be addressed.

Data Collection

Long-term rainfall data is to be acquired from at least one of the following sources:

- Daily read gauge operated by the Bureau of Meteorology at Walter Road Ingleside
- Tipping bucket rain gauge at the Narrabeen Creek crossing of Macpherson Street (operated by Manly Hydraulics Laboratory)
- Tipping bucket rain gauge at the Warriewood Sewage Treatment Plant (operated by Australian Water Technologies).

Stream gauging data appropriate to the sector is to be collected by the proponent and used in the development of the water cycle assessment. If combined with a water quality-sampling program, then baseflow contributions can be estimated from the recession limb of storm hydrographs.

Stream gauging is to take the form of spot gaugings using an approved hydrographic technique, which is to be coincident with water quality monitoring campaigns (Section 4.2). During event monitoring, rising limb, peak and falling limb gauging is to be carried out. Any stream gauging is to be undertaken in accordance with AS 3778 “Measurement of water flow in open channels”(under revision).

In addition to locally collected data, three automatic water level recorders are currently in operation in the Valley:

- Narrabeen Creek at Macpherson Street,
- Fern Creek at Garden Street and
- Mullet Creek at Garden Street.

In addition to this, some limited stream gauging was undertaken at eight sites as part of the Integrated Water Management Strategy (1997).

Infiltration estimates are to be supported by infiltration testing, such as double-ring infiltrometer testing.

Modelling

There are a number of recognised yield models that would be appropriate for a water cycle assessment. The Applicant is required to demonstrate to Council the suitability of any model chosen for this purpose.

Coupling of the water balance model and the water quality model is suggested in Section 4.3.1 which also contains further details of modelling requirements of water quality.

4.1.2. Assessment of Developed Conditions

The existing water cycle assessment is to be used as the basis of comparison with the developed case with various water management practices proposed within the development area (e.g. infiltration, reuse strategies such as rainwater tanks).

Proposals are to contain a comparison with the existing balance, and demonstrate how measures are to be implemented to ensure no adverse impact particularly with respect to frequent flows.

Further details of the selection and assessment of potential options are provided in Section 4.6.4.

4.2. WATER QUALITY ASSESSMENT

A water quality monitoring plan is to be prepared along with a water quality monitoring data report and a water quality assessment for the existing (pre-development) and post-development condition. This plan, the data and the assessment are to form chapters of the Water Management Report.

4.2.1. Establishment of Existing Conditions

The existing water quality conditions of the creek systems are to be established through monitoring and reporting of:

- physico-chemical water quality
- sediment quality
- ecosystem sampling.

These baseline data aid in the assessment of the impact of the development and ensure that the development is ecologically sustainable.

Overview

The first part of this aspect of the Water Management Report is to present a water quality monitoring plan.

The second part of this aspect of the Water Management Report is to present an assessment of the available data at the time of the submission of the report (i.e. existing data for the area or data collected under the monitoring plan).

All samples collected for analysis must be tested by a NATA certified laboratory with details of the Laboratory certification to be provided within the Monitoring Plan. Copies of all original data testing certificates from the laboratory are to be provided in reports. Information detailing the laboratory requirements for collection and preservation of dry and wet weather samples should also be provided in the Monitoring Plan.

The performance objective for monitoring is to ensure early detection of any significant risk to the health of the waterway and the public through pollution and habitat change during the development phase. A consistent sampling strategy has been proposed across all sectors in order to clearly identify any health risks and the evolution of waterway health throughout the development process. Monitoring is a vital component of the corrective action strategy within the environmental management plan to be prepared by the Applicant (Section 4.3.5).

Existing water quality data for the Warriewood Valley was collected as part of the Integrated Water Management Strategy (1997) which involved surface sampling at five sites to provide a limited baseline dataset. In addition to this data, event monitoring has been undertaken via automatic samplers installed at the three water level recording sites i.e. Narrabeen Creek at Macpherson Street, Fern Creek at Garden Street and Mullet Creek at Garden Street.

Water Quality Monitoring Plan

A water quality monitoring plan is to be prepared and commenced prior to the granting of a Rezoning application. The monitoring plan is to be designed specifically to establish the water quality and ecological characteristics of the riparian watercourses in the sector. The plan must relate monitoring to both the characteristics of the catchment, the creek system and prevailing climatic conditions. Guidelines for water quality monitoring can be found in AS/NZ5667.6: 1998 "Water Quality Sampling - Guidance on Sampling of Rivers and Streams".

The level of detail required for each approval stage is shown in Table C1 in Appendix C.

Monitoring Sites

Monitoring sites (at least three sites) are to be located in the creek channel near the upstream and downstream ends of each sector and at least one site within the sector on a major sector drainage line leading to the creek as a minimum. As a guide, the Rezoning application is to provide a plan with the sampling locations clearly identified and referenced for future reporting purposes to Council. Whilst the locating of sites at the upstream and downstream ends may produce results which indicate similar water quality at the upstream and downstream reaches of a sector, these results do not necessarily support the view that the sector does not contribute to exceedence of water quality objectives for the stream. It may be that the sector contributes at the same level as the incoming water.

Where significant portions of the Sector (i.e. greater than 20% of the sector) do not discharge into one of the three main creeks, monitoring must be undertaken for these areas in addition to the other monitoring sites required.

Monitoring is also to be undertaken at the inflow and outflow locations in all water quality control ponds and constructed wetlands. In this instance, monitoring of flow is not necessary, although an estimate of flow velocity is to be noted. Under wet weather conditions, flow and water quality are to be monitored for physico-chemical parameters throughout the passage of the storm event, and loads estimated. The resulting reduction in inflow load for the event using the calculated hydraulic residence time can be related to the expected performance.

Monitoring sites must be reported in the monitoring plan and will be selected according to the following criteria:

- safe access to the site;
- avoiding upstream point sources of pollution (or the ability to simultaneously monitor the point source and the upstream location);
- ensure generally well mixed flow conditions, so that the water quality sample is representative of the conditions at the monitoring site;
- avoid the presence of physical structures that may influence water quality, such as weirs;
- power supply for event monitoring equipment if appropriate and

- compatibility with monitoring activities undertaken by Council, including the long-term stations installed on Narrabeen Creek, Fern Creek and Mullet Creek.

Once the developments are complete, Council will be able to rationalise the monitoring network based on the collected data and continue the monitoring to determine progress towards the long-term water quality objectives.

Measurement accuracy

Measurement accuracy is critical in determining possible impacts from the sector, and attention to the design and implementation of the water quality monitoring plan will assist in resolving any uncertainties. The accuracy of the measurements using in-situ probes or laboratory detection limits is to be clearly stated in the report.

Types of Monitoring

There are three types of monitoring relevant to the assessment of the health of the waterways:

- Water Quality Monitoring (discrete sampling)
- Rapid Biological Assessment and
- Sediment Toxicant Monitoring.

The discrete sampling monitoring is designed to protect the aesthetic, recreational and environmental values of the creek systems. As suggested by the ANZECC (1999) guidelines, where protection of aquatic ecosystems is a value, the best measure of overall waterway health is direct biological assessment. Sediment toxicant monitoring is included since many pollutants can be attached to sediments and the prevailing conditions may cause pollutants to transfer between the different media.

Monitoring before the development will give a broad range baseline dataset of standard parameters by which the impacts of the development can then be measured as outlined in Section 4.2.2.

Water Quality Monitoring (Discrete Sampling)

Monitoring is to be undertaken under both Dry Weather and Wet Weather conditions.

- Dry weather monitoring is to be undertaken on a regular three monthly basis.

- Wet weather samples are to be taken for at least three (3) events spread evenly over the year where the rainfall is predicted to be greater than 20mm over the catchment in a 24-hour period. Wet weather sampling is to target the rising limb and the falling limb of the hydrograph, with at least one sample on the rising limb and one sample on the falling limb.

- Monitoring in wet weather is also to be sufficient to detect any significant sewer overflows or leaks.

Rapid Biological Assessment

Habitat monitoring is required as part of biological and toxicant monitoring to establish the long-term ecological health of the creek systems. The Biotic Index SIGNAL has been selected as the most appropriate and consistent method of measuring the biological activity using macro-invertebrate indicator animals (Chessman, 1995).

The SIGNAL index has been developed for South Eastern Australian waters, with each family assigned a grade between 1 and 10 depending on the tolerance to common pollutants (higher values represent lower levels of tolerance).

SIGNAL indices are classified into five levels:

- less than 4 = severely impaired, very poor water quality
- 4-5 = moderately impaired, poor water quality
- 5-6 = mildly impaired, fair water quality
- 6 -7 = unimpaired, good water quality
- >7 = unimpaired and rich in sensitive taxa, excellent water quality.

The monitoring sites for SIGNAL index assessment are to be in the channel at the upstream and downstream ends of each sector. The Rezoning application is to provide a plan with the sampling locations clearly identified and referenced for reporting purposes to Council.

The monitoring is to be at least yearly, with the first analysis provided within the Rezoning application, and the second before any construction has occurred.

Sediment Toxicant Monitoring

Toxicant testing of bed muds/sediments is required. Testing is to be undertaken coincident with the Rapid Biological Assessment, at the upstream and downstream limits of the Sector on the main watercourses. Testing is required for:

- Metals (details of specific metals required are listed in Appendix C)
- Organochlorine pesticides
- Oils & greases.

Monitoring Period

The frequency of instantaneous risk water quality monitoring, rapid biological assessment and sediment toxicant monitoring is detailed in the sections that detail the requirements of this monitoring above and in Appendix C.

All monitoring is to commence before the Rezoning application is submitted and is to continue until 'Handover' in accordance with the monitoring and reporting detailed in this Specification.

Reporting

The Water Quality Monitoring Plan should form a section of the Water Management Report.

For data collected, the following information is to be included as a section in the Water Management Report for pre-development monitoring and then as subsequent three monthly reports (as outlined in Section 3.4) for all types of monitoring:

- objectives of the monitoring program;
- limitations of the program;
- map indicating the location of the monitoring sites;
- description of the monitoring site's catchment, including catchment area, land use, and estimated impervious fraction;
- description of the rainfall patterns during the monitoring period. A figure indicating the daily rainfall and monitoring dates can be useful;
- summary of the sampling techniques;
- summary of the analytical techniques, including detection limits;
- QA/QC procedures;
- any factors which may have affected the results;
- the laboratory test certificates (can be included in an Appendix).
- a discussion (including graphs) on the influence of season and flow conditions on the monitoring results;
- a comparison between the observed pollutant concentrations and the long-term water quality objectives for ecosystem protection (Appendix C).

The minimum requirement for the Rezoning application is the inclusion of results of initial water quality sampling for wet and dry weather. Subsequent monitoring results are to be included in the Development Application, Construction Certificate, Subdivision Certificate and Handover reports.

For an event report, the report must include the following additional information:

- a table containing the event date, approximate runoff volume (or depth) based on spot or continuous gaugings, Event Mean Concentration (EMC) and load.
- event rainfall depth, peak flow and peak concentration rate.

4.2.2. Assessment of Developed Conditions

The existing water quality, as determined by monitoring, is to be used as the basis for comparison of various water quality management practices proposed within the development area. A comparison of during construction and post construction water quality data with baseline data is required to demonstrate how measures have ensured no adverse impact, and if possible to enhance the water quality, particularly with respect to dry weather flows.

Compliance will be assessed by Council based on compliance of the median recorded value with the specified criteria listed in Appendix C under short, medium

and long-term conditions. **Note that detailed criteria are set out in Appendix C for all monitoring locations and stages of development.**

Further details of the assessment of developed conditions and the selection and assessment of potential mitigation options are provided in Section 4.3 – "Water quality management".

Reporting

In addition to maintaining the same level of reporting outlined for the existing case (Section 4.2.1), reporting for the developed conditions in either the Water Management Report or the three monthly reports needs to include a section relating to monitoring undertaken for all stormwater quality improvement devices (SQID's) (identified in Section 4.3) within the Sector and must also include a discussion of retention time and effectiveness. The report shall detail measurements from all majors SQID's but comments in generality can be submitted on the performance of smaller devices such as vegetated filter strips. As outlined in Section 3.4, monitoring reports are to be submitted regularly, and at a minimum of a three monthly basis.

Once development consent is granted by Council, original laboratory analysis reports and details of site location, date and time of sampling are to be forwarded to Council or Council's nominated representative three weeks after an event (dry or wet weather) where data has been collected and analysed. A summary report of the event should then be prepared to be included in the three monthly reports as outlined in Section 3.4.

Council has separately engaged a consultant to compile and archive all water quality data collected throughout Warriewood Valley.

4.3. WATER QUALITY MANAGEMENT

A Water Quality Management Assessment is to be prepared detailing the pollutant load modelling for the existing (pre) and post development conditions and the proposed measures to reduce pollutant loads. This assessment is to form a chapter of the Water Management Report.

Overview

The objective of this aspect of the Water Management Report is to develop and design relevant components of an integrated catchment and corridor water quality management strategy that will deliver the water quality outcomes sought by Council as expressed in this Specification.

Council does not seek water quality outcomes which establish that all urban runoff meet ANZECC Ecosystem Protection (1999) criteria, rather that the long-term average dry weather concentrations in the watercourses meet ANZECC ecosystem protection standards and that long-term wet-weather flows in the watercourse generally meet ANZECC guidelines. Specific standards have been developed for in-sector monitoring applicable to wet or dry weather stormwater discharge concentrations. However, as a minimum, a 'no worsening' of existing runoff quality is required. Within each sector, a segment of riparian corridor (the private buffer, Section 4.4) is available to assist in the further treatment of runoff water and baseflow and the design of the water quality treatment functions of the corridor are an integral part of the water quality treatment train.

The means by which the long-term water quality objectives for the creek are to be met is by inference using a load-based approach (outlined in Section 4.3.3). It is not feasible at the present time to determine the long-term constituent concentrations in the creeks with confidence with current numerical techniques and knowledge in the field of water quality modelling and management.

Council recognises that there are some Sectors that have existing urban development in their upper catchment and these areas drain through the Sector to the creeks. Due to the complexities in the nature of the management of stormwater quality for these areas, Council will be seeking to utilise source control techniques in these upper catchment areas and does not require Applicants to cater for the management of water quality draining from these locations. The conveyance of flow from these areas is discussed in Section 4.5 of this Specification.

4.3.1. Establishment of Existing Conditions

The existing constituent loads from a site are to be determined using a daily load model with adopted parameters (such as event mean concentrations) confirmed by monitoring (Section 4.2) where possible.

The greatest change in pollutant loading characteristics occurs for frequent storm events. Non-urban aquatic ecosystems are generally accustomed to pollutant loads from large and infrequent events, which will contribute the majority of the annual

pollutant loading from a sector. Thus, a daily water quality modelling approach is advocated.

The daily water balance model developed for the Water Cycle Assessment (Section 4.1) could then be coupled with a constituent load model to determine the existing loads from the current land use on the sector to be developed. The model is to be discretised into appropriate subcatchment sizes in order to provide useful outputs to assess the developed scenario (e.g. provide the input loads to proposed water quality control devices). Consideration of three scenarios is to be made:

- a wet year (90%ile rainfall),
- an average year (~50%ile rainfall) and
- a dry year (10%ile rainfall).

An assessment of the daily loads of Total Nitrogen, Total Phosphorous and Suspended Solids is required. A guide to appropriate event mean concentrations for various existing land uses to be adopted in provided in Section 4.3.3. Results are to be compared with reported annual loads from similar land uses such as those from the AWT Stormwater Monitoring Project (under the Clean Waterways Project) (AWT, 1995a, b).

A similar approach to the assessment of the existing conditions for this type of development is advocated in the NSW EPA "Managing Urban Stormwater: Council Handbook" (1997).

4.3.2. Stormwater Quality Improvement Devices

Types of Devices

Water quality treatment is to be provided throughout each sector, through controls within individual lots, private property or public land. The requirements within individual lots are covered in the Water Quantity Management Section of this document (Section 4.3), while the remainder of the drainage system is generally to be controlled by the following water quality facilities:

- water quality control ponds/constructed wetlands for water quality control;
- filter strips
- water quality devices and
- other stormwater quality improvement controls.

In light of the nature of pollutant loading, the design storms adopted for the assessment of runoff quality control facilities should be less than the 100% AEP (the 1 in 1 year average recurrence interval) storm event. A significant proportion of the long-term runoff volume from an urban catchment occurs from frequent flood events and from a component of the larger events. Most proprietary stormwater quality improvement devices are to be generally designed for, and cater to, the 1 in 3 month storm event.

Water Quality Control Ponds/Constructed Wetlands for Water Quality Control

Water quality control ponds are to be used where possible as part of a treatment train system to reduce the pollutant loads exiting each sector. Where possible, a single pond/wetland should be utilised for each Sector as opposed to multiple ponds to reduce maintenance and maximise treatment efficiency. These systems are to be off-line from the main creeks. All areas of each sector are to be drained to the pond/wetland where ever practicable. To minimise the maintenance load on these devices adequate pre-treatment of flows must be implemented. Alternatives to water quality control ponds will only be considered if full analysis, justification and certification of performance is provided.

These ponds are to be located within the private buffer strip areas (Section 4.4). Any alternate proposal to locate a pond/wetland fully or partially in the public buffer strip will only be considered in exceptional circumstances. In these situations, the full cost of the construction of the pond/wetland shall be borne by the Applicant and no credit toward Section 94 contributions shall be applicable for the land and works where the functionality of the corridor is reduced. In addition to the requirement for the pond/wetland to be located in the private buffer strip, the pond/wetland must also lie above the 5%AEP flood level, except in Sectors 15, 17 and B. Also, apart from Sectors 15, 17 and B, the invert of the ponds in all other sectors should be such that the local groundwater is not intercepted by the pond.

Additional storage may be provided within these ponds in order to cater for a portion of the on-site detention requirements for the sector.

A long-term maintenance schedule will be required to ensure the efficient functioning of these ponds. A mosquito risk assessment is to be presented to evaluate the potential impact of any water quality control structure/constructed wetland.

Filter Strips

Filter strips are to be provided between stormwater discharge points and the waterway where sub-catchments cannot practicably be drained to a water quality control pond. The discharge points onto these filter strips are principally to be provided within the private buffer strip area, however the filter strips may extend into the public creekline corridor (Section 4.4). Flow is to be effectively distributed across the filter strip by the construction of a suitable flow spreader.

Provision must be made to ensure that any public pathways are not affected by flows exiting these areas during more regular occurring runoff events (i.e. up to the 1 in 5 year flow).

Water Quality Devices

Water Quality Devices are to be provided throughout the sectors to provide for the removal of gross pollutants, oils, sediments and organic litter from public lands, such as roads, parks, etc.

These devices may be located either on the road reserve or within the downstream drainage system. They are to be designed to integrate with the overall water quality management measures for the sector.

Examples of potential devices can be found in the EPA Managing Urban Stormwater: Treatment Techniques (1997) document or in the DPWS Contract 19 document.

Other Stormwater Quality Improvement Controls

Other types of controls are detailed in the following documents:

- Managing Urban Stormwater - Treatment Techniques (EPA, 1997)
- Controlling Urban Runoff - Schueler, 1987.

SQID Management/Maintenance Plan

A plan for each sector is required that describes how all of the SQIDs proposed for the sector are to be operated and maintained including details on the frequency and type of maintenance and the means and location of disposal or recycling of materials captured.

Monitoring

Monitoring frequency, items to be sampled and method of analysis of samples for each water quality control structure are to be detailed. The maintenance regime of any ponds, infiltration swales and other water quality and quantity control structures are to be detailed, with responsibilities clearly set out.

Monitoring and reporting of water quality control facilities is to continue until Handover (See Table 3.2, Section 4.2 and Appendix C).

Ownership of Facilities

Where the runoff is collected from public roads, an easement/positive covenant must be created in favour of Council over any water quality control facility located on private land.

Council will take over maintenance of these facilities at 'Handover'.

4.3.3. Assessment of Developed Conditions

The ultimate goal of the assessment is to ensure that the developed conditions do not worsen the existing conditions and that the opportunity is taken to improve/reduce constituent loads towards the outcomes mentioned in Section 4.3 “Water Quality Management”.

Assessing the developed conditions involves altering the land uses in the model prepared for the existing case (Section 4.3.1) and adding into the model the proposed stormwater quality improvement devices (SQIDs) (Section 4.3.2). Alternatively, these devices can be assessed separately, using the model inputs.

The annual loads for the three years (wet, average, dry) modelled under the existing conditions are to be compared with loads generated under the developed case with the adopted controls.

The Water Management Report is to include the adopted event mean concentrations for the different land use types and these are to be comparable with those listed in Table 4.1 or the Report is to include a justification for the use of an alternate value (e.g. based on monitoring over more than five events).

Table 4.1 Suggested Event Mean Concentrations for Modelling*

Land Use	TN EMC (mg/L)	TP EMC (mg/L)	SS EMC (mg/L)
Urban**	1.50	0.30	100
Rural Residential	1.00	0.10	35
Horticulture	2.50	0.20	45
Pasture	0.50	0.04	15
Forest/Native Vegetation	0.32	0.03	10

*Sources for suggested EMC's include creek autosampler data, Lawson & Treloar, 1997, AWT, 1995
**Urban includes urban residential, commercial and light industrial

Assessment of the performance of various devices is to be undertaken using data from published best management practice documents such as:

- Managing Urban Stormwater - Treatment Techniques (EPA, 1997)
- The Constructed Wetlands Manual (DLWC, 1998)
- Managing Urban Stormwater using Constructed Wetlands, CRC for Catchment Hydrology, 1998
- Controlling Urban Runoff - Schueler, 1987.

It is noted that the state of knowledge of the performance of the various devices is rapidly changing and it is the responsibility of the Applicant to seek advice which can access the latest in this knowledge base.

Compliance with pollutant export goals is to be determined by either a zero net increase in existing load, or an increase of 20% on the load if the catchment was forested, whichever produces the minimum developed load.

4.3.4. Construction Phase - Erosion and Sediment Control

For the Construction Certificate, Erosion and Sediment Control Plans are to be detailed, with attention paid to effectiveness of works, the need for flocculation of fine sediments and maintenance of works both on a regular basis and after storm events. These plans are to be prepared in accordance with the Managing Urban Stormwater: Soils and Construction guidelines (Department of Housing, 1998).

4.3.5. Construction Phase - Environmental Management Plan (Soil and Water Aspects)

Development Consent conditions will require an Environmental Management Plan (EMP) to be prepared for the entire site. For the water quality aspects, the plan is to address both construction and post-construction/operational phases, and is to contain, as a minimum, for each phase:

- objectives;
- management measures, including staging;
- erosion and sediment control measures, and revegetation/landscaping planning;
- monitoring requirements;
- responsibilities;
- reporting procedures;
- measures for identification of incident or failure;
- corrective action.

Details of the submission and updating requirements for this plan are outlined in Section 3.4.

4.3.6. Reporting

Appropriate calculations for hydraulic and hydrologic design of all structures are to be provided, including details of water quality control pond design, and the formulae adopted for prediction of nutrient removal rates and faecal coliform reduction. For designs, the target removal rates for nutrients and sediment are to be clearly annotated on each design.

A section of the Water Management Report covering the monitoring requirements of all SQID's within a sector is appropriate. Once constructed, data and interpretation from monitoring of devices is to be included within the three monthly reports. Further details are also outlined in Section 4.2.2.

Details of the requirements for erosion and sediment control plans and environmental management plans are provided in Sections 4.3.4 and 4.3.5 respectively. Details of the submission requirements for these reports are outlined in Section 3.4 and Table 3.2.

4.4. WATERCOURSE AND CREEKLINE CORRIDOR PRESERVATION/RESTORATION

A Watercourse and Creekline Corridor Preservation/Restoration Plan is to be prepared outlining the existing condition of the creekline corridor and the proposals for rehabilitation of the watercourse and corridor. This plan is to form a section of the Water Management Report and must be completed for the Rezoning and Development Application stages irrespective of whether the works are to be constructed by the Applicant or the land is transferred to Council under the MPB option in the Section 94 Plan.

4.4.1. Overview and Objectives

The rehabilitation of the creeks and their associated buffer corridors is an essential component of the water sensitive urban design. A large proportion of the creeks are degraded and infested with weeds due to past poor catchment practices. Fern Creek has been considerably modified, with a section of the creek being piped whilst Narrabeen and Mullet Creeks are more natural systems but are under considerable pressure from current and past land uses.

The redevelopment of the Valley affords an opportunity to restore these modified systems to healthy ecosystems whilst maintaining their capacity for flood conveyance during high flows.

As such, the creeks and associated corridors in this context are to be designed to fulfil the following functions in an integrated sense:

- Retention of pervious areas within the sector to assist with preserving the water balance of the area.
- Provision of an increased distance from impervious areas to the stream which aids in slowing runoff and provides opportunities for filter strips to treat the runoff.
- Provision of meander space for the streams, which allows any long-term morphological changes to continue. Provided that these changes are very long-term, there is little likelihood of issues (such as encroachment of stream meanders on development) being created.
- Provision of effective flood conveyance to carry the 1% Annual Exceedence Probability (AEP) flows and interim flood protection works where required.
- Protection against streambank erosion. In addition to this, since buildings are not on the channel, minor streambank erosion does not become a major issue.
- Provision of aesthetic value for properties with riparian frontages.
- Allowing access to the corridor for properties not directly associated with the corridor through pathways.
- Provision of increased pollutant removal opportunity through extensive use of filter strips for treating roof water and other runoff from riparian properties. (i.e. properties that are adjacent to watercourses).
- Provision of a common link between open space areas (defined in the Valley Masterplan).
- Provision of habitat and wildlife corridors.
- Provision for the retention of significant stands of remnant vegetation.
- Retention of creekline morphology.

- Reduction in stream warming. Urban Streams without buffer areas and riparian vegetation have less shading, and the stream water temperature can be elevated. This increases the likelihood of water quality issues.

Note that to ensure continuity of the creek system and to prevent an ad-hoc approach, Council has engaged a consultant to prepare a concept design of the watercourse and creekline corridor for Narrabeen Creek and Fern Creek. This design can be made available to Applicants on request for the purposes of comparison with designs for each Sector. It is expected that Sector design's should adhere to this concept design except in certain circumstances which are to be identified by the Applicant.

4.4.2. Shared Creek Sections

It is recognised that there are a number of sectors that share portions of the creeks and that sectors upstream and downstream boundaries are at various points along creek reaches. Issues relating to the management of the rehabilitation of the creeks are therefore likely to arise given the nature of the development on a sector by sector basis. For example, sectors may be developed at different times and thus provide limited scope for co-operative creek rehabilitation as a result. This also presents issues with respect to flooding; the implications of which are discussed in Section 4.5.4.

There are a number of possible approaches to manage this issue including:

- co-operation between sector Applicants to rehabilitate the creek at the same time and potentially using the same design engineer to prepare the creek sections, creek planting schedule and other relevant documentation for both sectors
- after negotiation with the Applicant for an adjacent sector(s), rehabilitation of a portion of the creek across to the top of the opposite bank with possible MPB credit for any additional sections of the creek outside the sector to be negotiated under the Section 94 plan between Council, the Applicant for the sector in question and any other adjacent Applicants.

Regardless of the approach devised, any rehabilitation works will require a transitional section between rehabilitated and unrehabilitated areas to minimise weed intrusion and any potential flood impacts (further discussed in Section 4.5.4).

4.4.3. Establishment of Existing and Design Conditions

Data Collection

The existing creek conditions are to be established through survey of the creek (long section and cross sections at 25 metre maximum spacings and locations where there are existing hydraulic controls and where the channel cross section changes in width and/or depth). In the case of Fern Creek, some of the system is highly modified and survey of the surface will be necessary to establish the amount of earthworks required to re-establish the creekline.

In addition to survey, the geotechnical conditions of the creek bed and banks are to be established. Grab samples of bed and bank material are to be subject to sieve analysis and a reconnaissance is to be made of the creek bed to establish the locations of rock outcrops (bed and banks), existing pool and riffle sequences and existing eroding locations. Sediment grain size distribution data will be required for the design phase.

In addition to sediment sieve analysis, it is recommended that tests for potential and actual acid sulfate soils be undertaken as part of the site geotechnical assessment since the rehabilitation works to be undertaken may involve significant earthworks within areas that are highly likely to contain such soils.

During the reconnaissance, stands of vegetation to be retained are to be identified, mapped with mapping to include an overlay with information derived from any other available studies of the area.

Design Flow Conditions

Design flow conditions have been established through hydrological modelling of the catchment using the RAFTS model (XP-Software, 1992) for the critical two-hour duration storm. Details of design flows on a sector by sector case for the post-developed peak flow conditions are provided as a table of upstream and downstream flowrates in Appendix B. It should be noted that the post-developed condition is contingent on the appropriate provision and design of on-site detention for all sectors (Section 4.6).

4.4.4. Creek Design Requirements

An overview of basic design guidelines and references to suitable approaches has been provided to aid the reader in determining the suitability of their design approach.

There are a number of essential design requirements that need to be fulfilled. These are:

- Corridor width requirements
- Environmental flow and flood conveyance requirements
- Channel section and batter slope requirements
- Planting and integration with the Landscape Master Plan
- Fencing restrictions
- Details for cycleway and road crossings
- Details for stormwater discharge points.

Basic Design Guidelines

The design of 'natural channels' is an extension of stream restoration, involving the creation of channels with the attributes of natural watercourses. These attributes include:

- A meandering plan form in dynamic equilibrium with site characteristics.
- A main channel with a floodplain (principally in middle and lower reaches).
- A series of pools and riffle zones (rapids).
- Native riparian and floodplain vegetation.

Waterway design is to be in accordance with guidelines such as:

- Guidelines for Stabilising Waterways, Standing Committee on Rivers & Catchments, Victoria (1991)
- Guidelines for Natural Channel Design, I. D. & A. (1996)
- A Rehabilitation Manual for Australian Streams, CRC for Catchment Hydrology (1999).

These guidelines refer to techniques such as the use of 'regime theory' with approaches published by various researchers in the field of fluvial hydraulics (e.g. Simons and Albertson, 1963). Calculations are to be provided in the Appendices of the Water Management Report to demonstrate the use of these techniques in the design of the channel.

Many of the overall considerations for stream restoration apply to natural channel design. In particular, consideration of the ultimate catchment development longitudinal zonation of ecological and geomorphologic processes is important. Each of these design objectives are to be addressed and acknowledged in the creek design section of the Water Management Report submitted with the application.

Essential Design Requirements

Corridor Widths

Average creek corridor widths have been set in the Warriewood Valley Development Control Plan generally at a 100m corridor width. Generally, public ownership corridor widths have been set at 50m on all creeks with the exception of some sections of Narrabeen Creek upstream of the proposed detention basin site, where the width is 30m. Private ownership buffers of 25m either side of the public buffers are required in all areas of development. Council has produced detailed documents, which show the extent and locations of corridors within the release. The Section 94 plan for Warriewood Valley details the corridor widths required for each sector.

Average corridor widths are provided because these will vary according to the adjoining land use. Integration of all the functionality aspect of the corridors may necessitate a varying of private buffer strip width, which is encouraged. The criterion for evaluation of the average width for the private buffer strips is that the average width over the total corridor length is 25m.

Concept Plans showing the expected aspect of the corridor are provided in Figures 2, 3, 4 and 5. Figure 2 shows a concept plan figure of a creekline corridor; Figure 3 shows a typical concept section of a creekline corridor. Figures 4 and 5 show examples of detailed plans. Figure 6 provides general details of landscape treatments required within the creek and corridor.

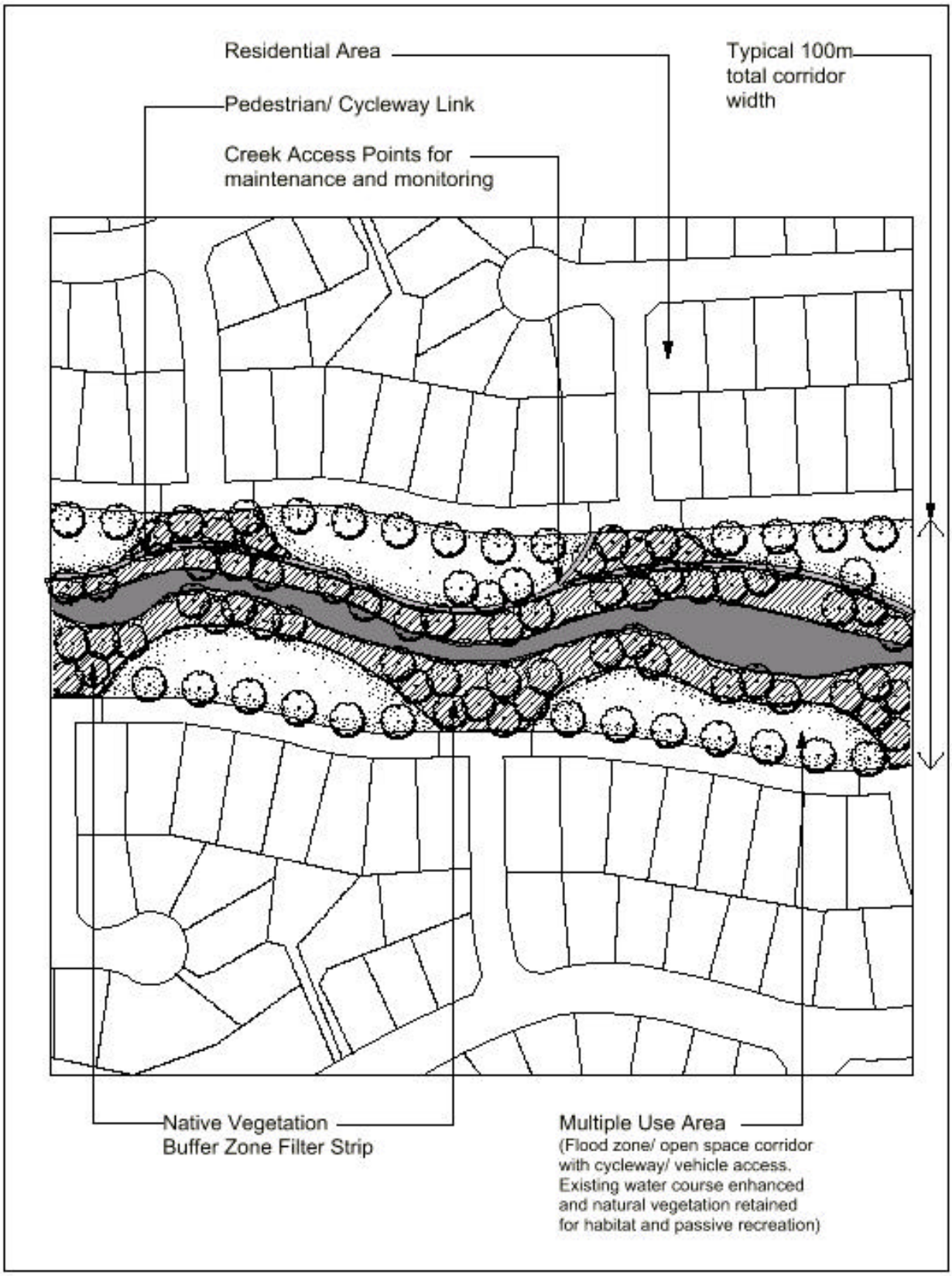


Figure 2: Concept Plan - Typical Creekline Corridor
(adapted from Sharpin et al, 1995)

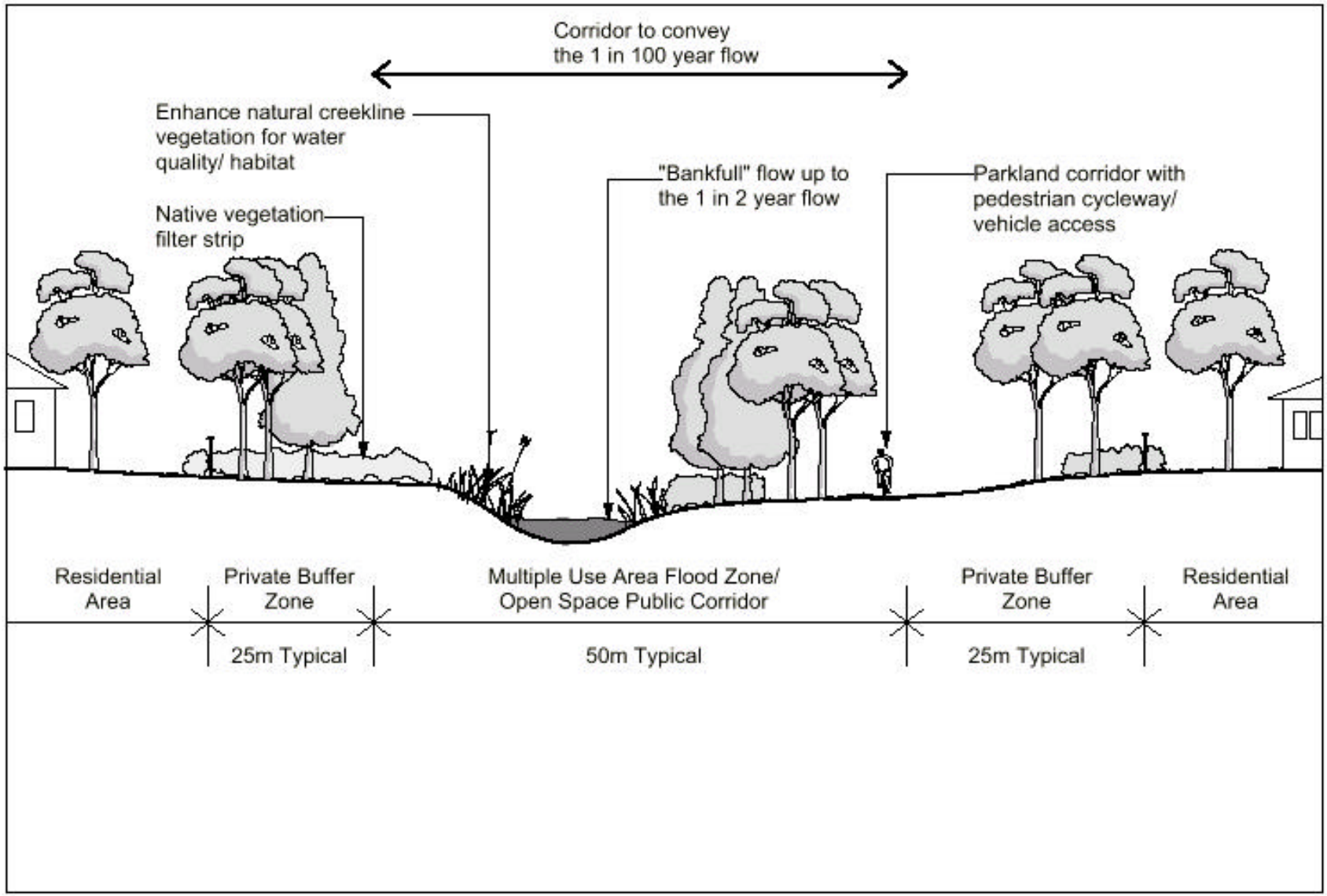


Figure 3: Typical Section - Creekline Corridor

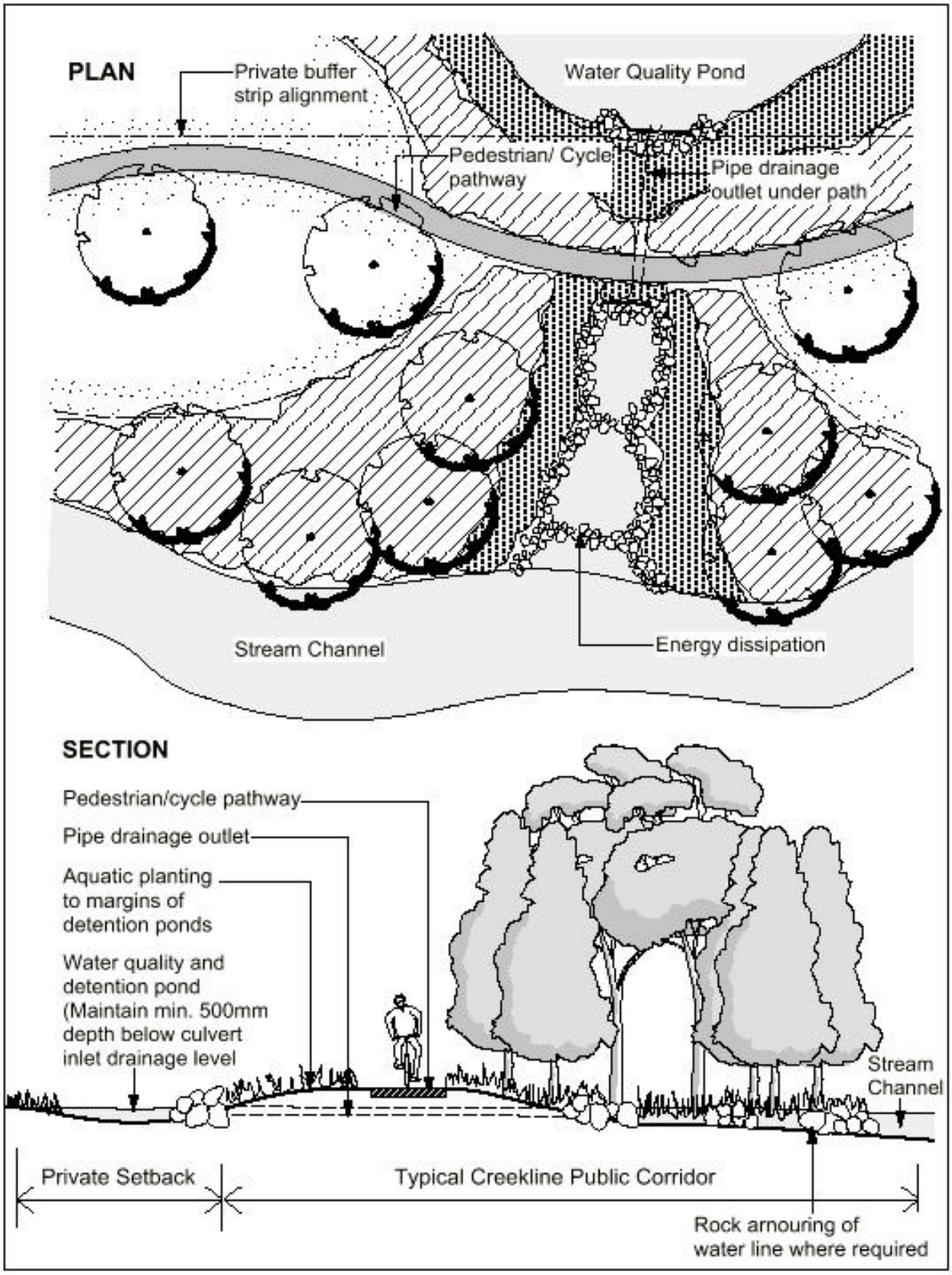


Figure 4: Concept Plan - Water Quality Pond and Outlet

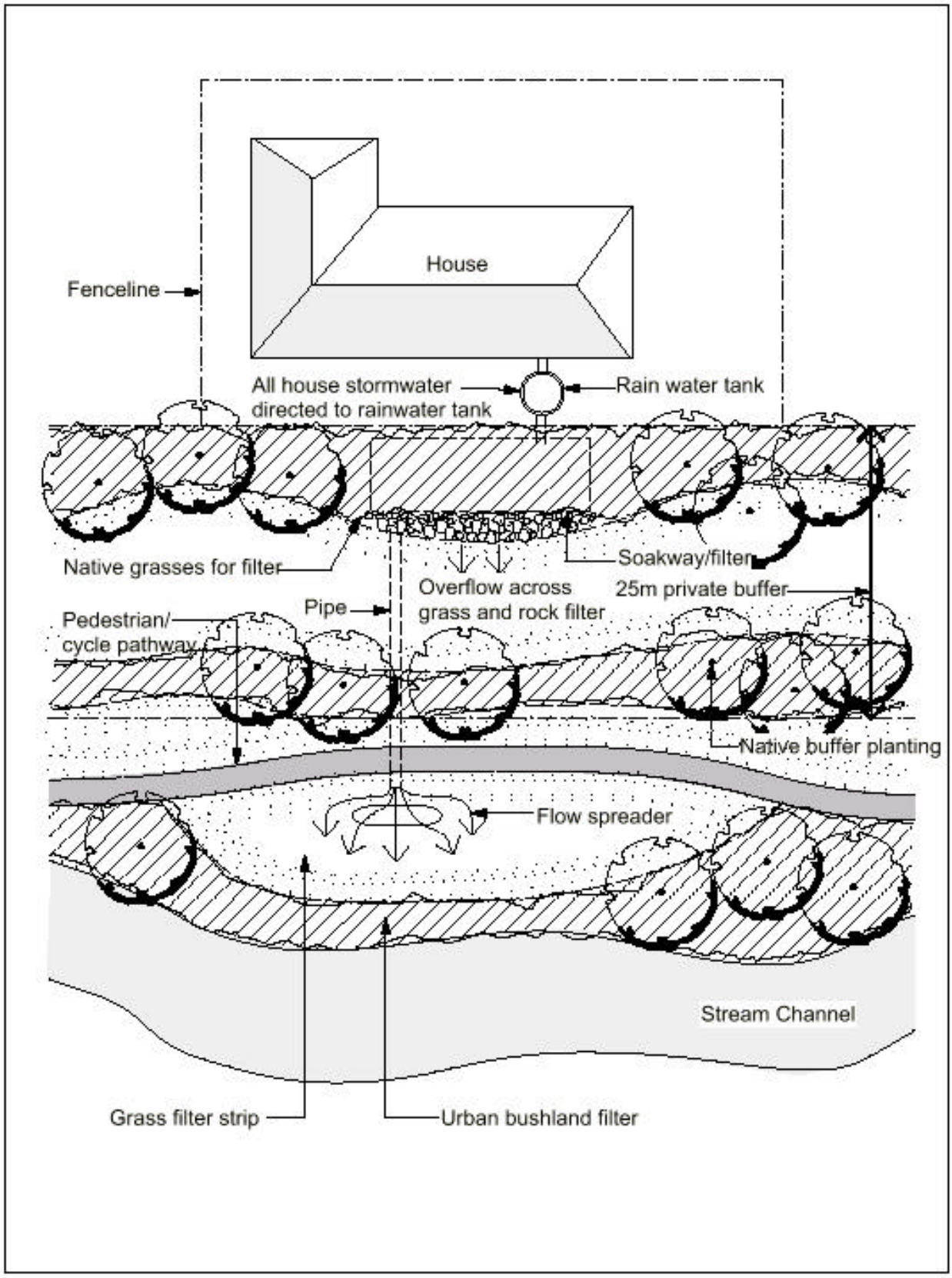


Figure 5: Concept Plan - Dwellings Adjacent to Creekline Corridor

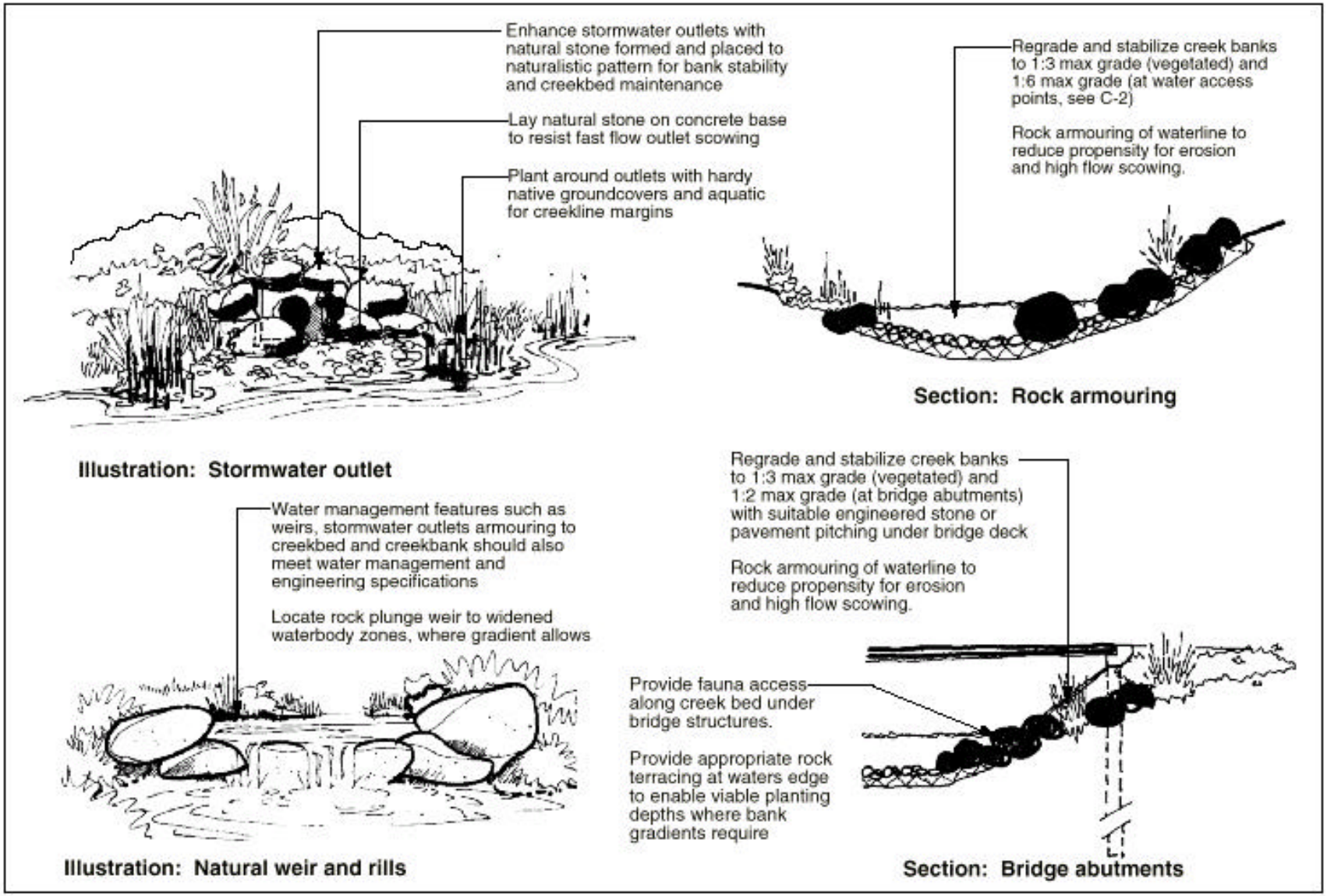


Figure 6: Typical Section - Creekline Landscape Treatments

Environmental Flow and Flood Conveyance

In order to establish a channel and corridor with sufficient variability in depth to support a healthy ecosystem, the in-bank creek channel portion of the corridor must be designed to carry a maximum of the 50% AEP flood flows below bankfull levels. As outlined in Section 4.4.3, the design flood flows are provided in Appendix B.

Note that in the area where the Swamp Mahogany stand has been identified (Sectors 4 and D, Section 1.4), the current area is inundated on a frequent basis. Any creek design needs to consider this issue and accordingly provide for the continuance of this pattern of inundation as well as allow for flood flow conveyance.

Further details on flood conveyance requirements and flood planning levels for various amenities within the creek corridor can be found in Section 4.5.

Channel Sections and Batter Slope Requirements

The channel sections are to be constructed broadly in line with the present channel alignment and bed levels, with some straightening where severe restrictions presently exist. The aim of the works is to create a gently meandering stream within the multi-use corridor.

Design batter slopes are to be no greater than the following (depending on the bank materials and any proposed stabilisation works):

- 1V:3H for regularly wet areas and 1V:6H for water access points (defined as being the level to which daily flows rise to up to the 50% AEP or 1 in 2 year flow)
- 1V:6H for frequently inundated areas (defined as being up to 20% AEP peak flood level)
- 1V:8H for areas above the 20% AEP peak flood level.

It is recognised that in some instances, the batter slopes may need to be steeper than those prescribed above. It is expected that the majority of the batter slopes would conform to those prescribed above. Where constraints exist to result in steep batters for short sections of the environmental flow section of the creek (e.g. 1V:1H or even 2V:1H), these batters should be stabilised in an appropriate manner. In the case where steep batters cannot be avoided without a transitional area between cycleways/pedestrian tracks, it is recommended that dense vegetation be planted on and adjacent to the banks of the environmental flow channel to provide a natural barrier for safety purposes.

Note that design flowrates at the upstream and downstream ends of each sector for various events are listed in Appendix B.

A corresponding list of the type of vegetation required in these areas can be found in the Landscape Masterplan for Warriewood Valley (2000).

Planting and Integration with the Landscape Master Plan

This aspect of the Water Management Report is to be prepared in close consultation

with the Landscape Masterplan and Design Guidelines (December, 2000). Table 4.2 outlines the important aspects of vegetation management and planting.

Table 4.2: Vegetation Requirements

Requirement	Comment
Maintain existing native vegetation	• From the perspective of vegetation management, the most important principle is to maintain significant existing native riparian vegetation where practical. • During development of the site, remnant vegetation must not be removed without agreement from Council. The Applicant must comply with Council's vegetation management policies including the Landscape Management Policy (1993), the Landscape and Vegetation Management Development Control Plan (1999), the Draft Management Plan for Threatened Fauna (1998) and the Draft Development Control Plan for Biodiversity Conservation (1999).
Remove exotic vegetation	• Exotic vegetation, particularly noxious weeds, must be removed, unless the vegetation has a bank stabilisation role. In such cases, the exotic species could be partially removed to enable the establishment of native species, with the remaining exotics removed at a later date.
Restoration of native vegetation	• Restoration of riparian zones can generally be undertaken by planting locally native vegetation. If only limited riparian vegetation remains, a list of appropriate species is given in the Landscape Masterplan for Warriewood Valley (2000) and further information can be obtained from Council.
Continuity	• Major discontinuities in the riparian zones must be avoided to facilitate wildlife movement, provide continuity of input to stream ecosystems, minimise erosion and treat overland flow.
Planting Schedule, Layout and Densities	• The planting must be based on recognition of the zonation in plant communities which occurs from the waters edge, to the top of the bank, and then on the floodplain. Longitudinal zonation of vegetation will also occur, from upland to lowland streams. • Planting can also account for the different streamflow velocities and inundation frequency likely to be experienced by the vegetation. • In some areas, the centre portion of the waterway will consist of a series of shallow ponds with a maximum low flow depth of 0.5 metres. This area could be planted with those aquatic species listed in the vegetation list. Aquatic plantings must be at a minimum density of 4 plants per m^2 for cells or tubes with a volume of 200mL or more. • Listed littoral vegetation could extend up the 1:3 slope of the waterway. Beyond this, the vegetation would consist of water tolerant grasses and groundcovers. The lower area must also be planted with a range of locally native trees such as those listed in the Landscape Masterplan for Warriewood Valley (2000). Trees are to be planted at a rate of 1 plant per 10 linear metres of waterway. Understorey shrubs must be selected from the list below and be planted at 1 plant per 5 linear metres. Higher areas in the floodway and in buffer strips could be planted with native grasses and ground covers with 6 cells or greater per square metre. • Structural works or exotic plants may be required when active erosion areas are replanted until the new vegetation becomes established (when sterile annual or non-invasive exotic vegetation can be replaced). • Windbreak plantings may also be necessary to assist with riparian vegetation establishment in exposed areas.
Inhibiting Weed Growth	• The use of appropriate locally native plant species at sufficient densities to provide competition to weeds, although weed management may be required until the native vegetation is established. Mulch can be placed above the 5%AEP flood level, whilst weed matting may be provided below the 5%AEP flood level.

Fencing Restrictions

Fences at the rear of riparian properties are to be limited to open mesh systems with opening sizes not smaller than 0.1m to allow unrestricted wildlife migration. The Warriewood Valley DCP contains a full description of fencing requirements with conceptual sketches.

Pedestrian, Cycleway and Road Crossings

The shared pedestrian path and cycleway is to be located at the outer edge of the public corridor as shown in Figures 3 and 4. The proposed location of the path/cycleway is shown on the Landscape Masterplan (2000) as well as on the Warriewood Valley Concept Masterplan (2000). The path/cycleway should avoid existing native vegetation.

There are a number of issues that are to be considered and reported when submitting designs for embankments and crossings associated with watercourses. These include:

- Facilitating the upstream and downstream movement of fish and invertebrates where this movement is significant. Drop structures and pipe culverts can hinder this movement.

- Minimising scour downstream of the waterway crossing. Increased flow velocities through waterway crossings may scour the channel, resulting in erosion and habitat loss.

- Assessing the impacts on upstream channel erosion of any creek 'realignment' works associated with waterway crossings.

- Acknowledging that watercourses are in a state of 'dynamic equilibrium', and can change their location and form under natural conditions. Waterway crossings may restrict this dynamic process or be undermined by the process.

- Providing an appropriate waterway area and geometry for creek crossings to minimise impact on upstream flood conditions.

- All waterway crossings are to be free-spanning structures with piered approaches. Culverts are strongly discouraged by both the Department of Land and Water Conservation and NSW Fisheries. The deck obvert of spans should be set at the appropriate flood planning level listed in Section 4.5.

- Where cycleways and walkways are designed to cross under bridges, thereby exposing the population to risk from rising floodwaters, appropriate signage is to be provided (See Section 4.5).

Stormwater Discharge Points

Where sector drainage connects to the creek systems, as outflows from water quality control ponds/wetlands or discharge points from filter strips, the flow joining the creek

shall have parallel streamlines when joining the creek and are to be designed to include energy dissipation works. Headwalls and energy dissipation structures should have a natural appearance and should have their invert at the base of the creek to ensure there is no additional scour induced by their presence. Details of treatments of outlets are provided in Figure 6.

Where the MPB option is not taken up by the Applicant and the land is transferred to Council, any outlet structures that form stormwater discharge points that are constructed must comply with the above requirements and must be located appropriately with consideration of both the existing and design watercourse and corridor. Interim works may therefore be required.

4.4.5. DLWC Permits and Approvals

The issue of permits and approvals by DLWC is currently in a state of transition due to the enactment of the *Water Management Bill* (2000) (See Chapter 6).

Prior to the enactment of the Bill, the Rivers and Foreshores Improvement Act (RFIA, 1948) forms the legislative basis for permits and approvals issued by DLWC for creek works. The RFIA requires a Part 3A permit for works undertaken in or near water bodies. With respect to Part 3A permits, it is recommended that Applicants obtain a copy of the *'Guidelines on integrated development and the Rivers & Foreshores Improvement Act 1948*' from the Department of Land and Water Conservation (February, 2000).

With respect to permits already issued, the new Water Management Bill (2000) states that:

- *'A permit that, immediately before the appointed day, was in force under Part 3A of the 1948 Act is taken to be a controlled activity approval entitling its holder to carry out the activity specified in the permit on the land to which the permit relates, and is taken to be subject to the same conditions as it was subject under that Act.*
- *A controlled activity approval (as described in the Act) has effect for the balance of the term for which it was granted'*.

Following the enactment of the Bill, Part 3 of the new Act relates to approvals required. Approvals for creek works fall under the category 'Water Management Work Approvals' and 'Activity Approvals'.

With respect to Water Management Work approvals, the Bill states that:

'There are three kinds of water management work approvals, namely, water supply work approvals, drainage work approvals and flood work approvals.

A water supply work approval authorises its holder to construct and use a specified water supply work at a specified location.

A drainage work approval confers a right on its holder to construct and use a specified drainage work at a specified location.

A flood work approval confers a right on its holder to construct and use a specified flood work at a specified location within a floodplain.'

With respect to Activity Approvals, the Bill states that:

'There are two kinds of activity approvals, namely, controlled activity approvals and aquifer interference approvals.

A controlled activity approval confers a right on its holder to carry out a specified controlled activity at a specified location in waterfront land or at a specified location in a water source protection zone.

An aquifer interference approval confers a right on its holder to penetrate or interfere with an aquifer at a specified location, or in a specified area, in the course of carrying out specified activities.

Note. *Examples of where an aquifer interference approval may be needed include mining operations, road construction and any other large scale activity that involves excavation.'*

It is the responsibility of the Applicant to check with the Department of Land and Water Conservation on the matter of approvals required and the status of the enactment of various parts of the *Water Management Bill*.

4.4.6. Monitoring

Monitoring and maintenance of engineered channels is necessary to detect bank erosion, widening, slumps, incision, aggradation and control excessive vegetation in the channel. As a guide, monitoring must be carried out after each major flow event, defined as greater than 50mm of rainfall in 24 hours measured at the Ingleside rain gauge (Section 4.1.1), or at an interval not exceeding six months. Monitoring must be carried out along the whole length of the channel with particular emphasis at bends and structures.

4.4.7. Reporting

This aspect of the Water Management Report is to provide information on:

- mapping of the existing creek systems through detailed survey overlain with the proposed creekline in both plan and cross section
- definition of corridor extents
- location of remnant species of vegetation
- monitoring and management (including an acid sulphate soils management plan - if required, vegetation management plan and mosquito risk assessment) .

Cross-referencing to water quality monitoring (Section 4.2) and flood protection (Section 4.5) is also required to demonstrate the addressing of these particular issues for the section of creek being considered.

The section of the report is to present and justify a series of sketches and drawings, which depict the proposed corridor alignment and creek channel sections. Remnant vegetation and proposed plantings are to be identified. Creek and corridor sections are to be provided at 50m centres for the Rezoning stage whilst the Development Application stage requires design sections at 25m centres maximum. All sections are to extend across the creekline to the opposite corridor extent to the far limit of the private buffer zone. For Rezoning applications, concept plans (such as those presented in Figures 2 and 3) are sufficient. For the Development Application, however, plans are to be more detailed (to Engineering drawing standards). The sections are to show the peak flood levels for various design events of the 50%AEP, 20%AEP, 5%AEP, 1%AEP and the PMF (See Section 4.5). Calculations and details of sections and the means by which the channel sizing is achieved (e.g. through regime theory) are to be included as Appendices within the report.

The report is also to include a description of the monitoring plan for the creekline corridor.
An acid sulfate soils management plan is to be prepared if there are actual or potential acid sulfate soils detected within the area to be restored.

A vegetation management plan for the site is required for the corridor restoration. The plan is to include the following information:

- Definition of each project task to be undertaken and its relationship to other tasks, how each task will be carried out and the likely duration of each task
- Identification of plant species - only local native species are to used as listed in the Landscape Masterplan (2000), species need to be identified from local plant stock sources and a check on any licences required
- Maps and diagrams of planting layout.

A mosquito risk assessment is to be presented to evaluate the potential impact of the corridor plan.

4.5. FLOOD PROTECTION

A Flood Analysis is to be prepared by the Applicant detailing design flood modelling pre and post development and for various interim conditions as set out in Section 4.5.5. This analysis should form a section of the Water Management Report and must be completed for the Rezoning and Development Application stages irrespective of whether the works are to be constructed by the Applicant or the land is transferred to Council under the MPB option in the Section 94 Plan.

Overview

Floodplain management in NSW falls under the jurisdiction of local Councils with assistance from the Department of Land and Water Conservation. Floodplain management aims to ensure that there is appropriate land use within the floodplain and that risks to life and property from floods are minimised.

The creeks within the Valley perform the function of both:

- environmental flow (also commonly referred to as 'low' flow or 'base' flow) conveyance and maintenance of biodiversity and
- flood conveyance.

The redevelopment of the Valley affords the opportunity for appropriate development within the floodplain with a policy of ensuring that the 1%AEP flood is carried within the creekline corridor (i.e. no residential development or significant amenities be placed within the 1%AEP flood extent). In addition to this, the Probable Maximum Flood (PMF) needs to be considered with its implications for flood hazards and flood evacuation.

The Floodplain Management Manual (Draft, 1999) and its predecessor the Floodplain Development Manual (1986) produced by the State Government provide guidance on the management of all aspects of flooding and further information can be found in these manuals.

4.5.1. Flood Behaviour in the Valley

Previous Studies

The existing flood behaviour of the creeks in the Valley has been assessed under two existing studies:

- Narrabeen Lagoon Flood Study (PWD, 1990)
- Narrabeen and Mullet Creeks Flood Modelling (Lawson & Treloar).

Applicants should also be aware that Pittwater and Warringah Council's engaged consultants in 2000 to prepare the Floodplain Management Plan for Narrabeen Lagoon.

The flood behaviour of Fern Creek has not been considered in detail in either of these studies due to its variable piped/open channel nature and the limited amount of development within the floodplain.

Existing flood issues have been identified for the lower reaches of Narrabeen and Mullet Creeks, with potential backwater flooding from Narrabeen Lagoon as well as flooding from the catchment. The Warriewood Wetlands provide some flood detention function, prior to the flows exiting to Narrabeen Lagoon and the wetlands can fill and cause flooding in the adjacent areas.

Techniques utilised for the PWD (1990) study have now been updated and it is not recommended that reliance be placed on the findings of that study. However, no other detailed information is available for the behaviour of Narrabeen Lagoon and its interaction with the Warriewood Valley creeks and wetlands and so some information needs to be derived from this report in the absence of more recent published studies.

The more recent flood modelling undertaken by Lawson and Treloar for Council provides a guide as to the hydraulics and behaviour of the existing floodplain. However, the model will provide limited assistance to Applicants for redevelopment scenario's since the significant changes in the creek cross sections will alter the flood behaviour, with new survey data required and creek design sections required to make an assessment of the post-developed flood behaviour.

Flood Mechanisms and Tailwater Conditions

Flooding in the catchment arises from intense rainfall and/or the backwater effects of Narrabeen Lagoon that forms the downstream boundary condition for all the streams in the Valley. The presence of the Warriewood Wetlands within the Valley is also a factor in the consideration of flooding.

Flood behaviour of the wetlands is controlled by catchment inflows and the tailwater condition within Narrabeen Lagoon (i.e. at the confluence of Mullet Creek with Narrabeen Lagoon, referred to as 'the confluence'). The Lagoon flood study (PWD, 1990) considered two tailwater conditions producing two alternate tailwater conditions at the confluence:

- a high tailwater condition of assuming the Lagoon level was at peak design level producing a level of 2.7 m AHD at the Mullet Creek confluence and

- a mean high water spring (MHWS) tide producing a water level in the lagoon of 0.6 m AHD at the Mullet Creek confluence.

The high tailwater condition corresponds to a 1%AEP event with a duration of 36 hours for the entire Narrabeen Lagoon system with an assumed closed entrance condition at the start of the storm and assuming the entrance was mechanically opened at a threshold water level of 1.3m. The low tailwater condition applies to a 1%AEP flood event occurring only within the Warriewood Valley superimposed on a mean high water springs (MHWS) tide and the same entrance condition.

At the lower Narrabeen Lagoon tailwater condition at the confluence, the weir downstream of Jacksons Road (level of 1.34 mAHD) will inhibit the Lagoon tailwater from penetrating into the wetlands area (Figure 1). The worst case scenario occurs when a flood event commences when the wetlands are 'full' (i.e. the water level is 1.34m AHD). The best case scenario occurs when the wetlands are dry at the start of an event, then storage and routing effects will occur with the wetlands capacity of the order of 79,000 m^3.

However, a check of the wetland volume as compared to the volume of flow during the 1%AEP flood event indicates that the 1%AEP volume is approximately 15 times greater than the volume of the wetland. This means that it is reasonable to assume that regardless of the wetland condition prior to a 1%AEP event, the wetland will fill rapidly and thus the peak is likely to be unaffected by the pre-flood condition. Only the timing of the peak may be affected by the pre-flood condition.

It is important to recognise that the high tailwater condition adopted for the PWD (1990) study may be excessive from a joint probability (flood-elevated ocean levels) perspective for the 1%AEP. However, in the absence of further modelling and assessment, the 2.7 m AHD level is accepted as being appropriate. This level would involve the tailwater drowning the weir downstream of Jacksons Road (at 1.34 m AHD) and filling the wetlands. The range of possibilities for the behaviour of the wetlands in flood also depends on the water levels within the wetlands prior to the event. If the wetlands are 'full' then the backwater effects will only serve to increase the water levels within the wetlands. If the wetlands are dry, then the Lagoon waters will overtop the weir and flow into the wetlands. The duration of overtopping is likely to be confined to a high tide period, however it is uncertain as to the volume of flow which might enter the wetlands causing them to fill.

The peak flood level for the wetlands from the PWD (1990) study has previously been reported as being 3.0 m AHD. This reported level has previously been adopted as the high tailwater condition. The MIKE11 model for the Warriewood Valley floodplain (prepared by Lawson & Treloar and calibrated to the April 1998 event) indicates that the peak flood level in Warriewood wetlands for the existing condition is 1.98 m AHD for the 1%AEP 1 hour storm for the low tailwater condition. However, the recalibrated model has not been run for the high tailwater condition. This value should be adopted with caution (due to limitations of the data within the model).

Therefore, available model results indicate that there is a wide variation between the low and high tailwater conditions. Since the joint probability of a flood within the entire Narrabeen Lagoon occurring at the same time as a flood within the Warriewood Valley has not been investigated, only engineering judgement can be used to set a level. It is likely that the probability is quite low that the Lagoon is elevated to the high tailwater level prior to a 1%AEP event in the Warriewood Valley. Therefore, uncertainties with respect to the modelling and the timing and coincidence of flood events in the Lagoon and the Valley may mean that adopting the low tailwater condition with some factor of safety (i.e. producing a level of 1.98 m AHD + say 0.5 m to make 2.48 m AHD for areas adjacent to the wetlands only) would be a more appropriate choice given the available information.

It should be noted that adopting a single value for the tailwater condition within the wetlands is only appropriate for steady-state modelling of flood behaviour (e.g. HEC-RAS modelling) and will provide conservative results.

4.5.2. Flood Planning and Design Levels for Development

To ensure that flooding at the downstream end of the Valley creeks is not worsened, the requirement for design flood levels is to ensure that there is a zero increase in the 1%AEP flood levels over existing conditions (except at the regional detention basin site upstream of Sector 1 where ponding is required to activate channel storage) and in special circumstances as determined by Council.

To achieve much of the reduction in the peak flood levels and flowrates, which would otherwise be exacerbated by the considerable increase in impervious surfaces, on-site detention (OSD) is required for all sectors. The requirements for OSD are presented in detail in Section 4.6.

It is imperative to note that the direction of state floodplain management policy in NSW is to consider all floods up to and including the Probable Maximum Flood (PMF) under the Draft Floodplain Management Manual (1999). The implications of this policy direction is that properties that lie within the extent of the Probable Maximum Flood may attract a notation on their Section 149 Certificate.

Consequently, the PMF and the 1%AEP flood extents are required to be plotted in plan to indicate any property areas that lie within the floodplain. This is required even if the PMF will be contained within the creekline corridor.

Flood planning levels and the requirements for various design events are shown in Table 4.3.

Table 4.3 Flood Planning Levels

Design Level	Requirement
50%AEP (1 in 2 year ARI)	• 50%AEP flow to be carried in-bank
20%AEP (1 in 5 year ARI)	• The level of walkways and cycleways adjacent to the creeks are to be above the 20%AEP flood level except under special circumstances (and exposed for only short duration's) • Water quality control ponds, filter strips and structures are to be above the 20%AEP flood level, and can be below the 1%AEP flood level but must lie within the private buffer area as outlined in Section 4.3.2.
1%AEP (1 in 100 year ARI)	• 1%AEP flows are to be carried within the public space corridors, and are to be further designed such that floodplain management and hazard management guidelines are accommodated to minimise risk to life • Flood extent to be mapped • Floor levels for properties adjacent to the creek are to be set at least 0.5 m above the 1%AEP level • Obverts of bridge decks of evacuation routes are to be set at least 0.5 m above the 1%AEP level
Probable Maximum Flood	• Evacuation Planning • Flood hazards and risk to life • Flood extent to be mapped

4.5.3. Flood Evacuation

Flood evacuation pathways are to be provided at regular intervals along the creek corridor. It is suggested that these evacuation pathways coincide with interallotment drainage and access points for non-riparian frontage lots to the corridor.

As part of the design of the corridors and the urban design of the sectors, appropriate signage must be placed on the walkway so that users are aware of the evacuation route in case of rising flood waters.

It should be noted that there are four major road crossings to be provided or upgraded to above the 1%AEP flood level for emergency access and evacuation purposes. These are:

- Ponderosa Parade / Macpherson Street at Narrabeen Creek (west)
- Macpherson Street at Narrabeen Creek (east)
- Garden Street at Fern Creek.

The road crossing of Boondah Road at Narrabeen Creek will be upgraded as outlined below.

Details of the works include:

- Bridges are to be provided over Fern Creek at Garden Street and Narrabeen Creek at Macpherson Street and the intersection of Ponderosa Parade and Macpherson Street. Each bridge will enable unobstructed conveyance of the 1%AEP flood flow to enable adequate emergency/ evacuation access to the entire release area during flood events. Pedestrian and cycle access are to be provided under each bridge.
- Macpherson Street between Boondah and Warriewood Roads is to be raised in addition to the reconstruction of the bridge over Narrabeen Creek. This will be in the form of a series of culverts or an extended bridging structure to cater for the widened floodway and to ensure no upstream backwater effects. Pedestrian and cycle access is to be provided under the raised roadway.
- Upgrade of Boondah Road to provide 1%AEP access to flood free areas of Boondah Road and the remainder of Boondah Road upgraded to 20%AEP protection including the reconstruction of the bridge over Narrabeen Creek.
- Additional pedestrian/cycleway bridges are to be provided over Fern Creek and Narrabeen Creek to provide access above the 1%AEP flood level to maintain continuity of the pedestrian/cycleway network.

4.5.4. Adjoining Creek Works (Interim Conditions)

Where applications relate to riparian corridors where development is not occurring at the same time for the neighbouring banks (upstream, downstream or across stream), then the application is to contain an interim flood protection plan. Works such as mounding or other means of flood protection are to be accounted for in the period where the proposal may be granted consent, but the other side of the creek corridor is not developed. Where proposals are submitted coincident with Development Application on the other sides of the creek or upstream of downstream of the sector,

details are to be provided to show how the flood protection approach is consistent with each side of the creek.

The interim flood protection plan is to be reviewed prior to Handover and any interim works that can be decommissioned as identified by this review are to be removed prior to Handover.

4.5.5. Reporting

The section of the Water Management Report relating to Flood Protection is to provide information on:

- Design flood modelling undertaken including model cross sections and assumptions
- Plans showing design flood levels (as described in Section 4.4)
- The application of any flood planning levels
- Interim flood protection works
- A flood evacuation plan.

All flooding assessments must extend a sufficient distance upstream and downstream to accommodate all likely hydraulic influences, such as potential overland flow paths from upstream areas, downstream culverts and tidal conditions.

Cross referencing to creek rehabilitation (Section 4.4) is also required to demonstrate the addressing of these particular issues for the section of creek being considered.

Tables of data and sections are to indicate the peak flood levels for various design events of the 50%AEP, 20%AEP, 5%AEP, 1%AEP and the PMF.

4.6. STORMWATER QUANTITY MANAGEMENT

A Stormwater Quantity Management Assessment is to be prepared to address issues of piped drainage and overland flow paths, on-site detention and retention and is to form a chapter within the Water Management Report.

4.6.1. Overview and Objectives

To ensure that adequate flood protection is afforded across the whole Valley including the existing developed areas in the downstream reaches (e.g. Warriewood Square and properties around the Warriewood Wetlands and Narrabeen Lagoon), stormwater quantity controls are to be implemented in each sector.

The objective of any stormwater quantity control is to limit post-development peak flowrates to the same level as pre-development peak flowrates.

The water quantity criteria is expressed as follows:

> "Post-development peak flows both from the sector and in the channel at the downstream boundary of each sector are not to exceed the pre-development flows for the full range of duration's and frequencies up to the 1%AEP level."

For the purposes of assessing the baseline (or pre-development) conditions for stormwater quantity management, it has been assumed that the peak flows are to limited to those from a 'rural' land use or in those areas where significant forest exists a combination of 'rural' and 'forest' land use. This allows for a responsible approach to flood management taking into account the sensitive nature of existing downstream features and developments.

Stormwater quantity management is to be provided by both detention and retention.

Detention can be provided in the following ways:

- On-site detention systems on a lot-by-lot basis for the short duration storms;
- Detention basins (either local groupings of lots or larger-scale basins); and/or
- Additional storage in Water Quality Control Ponds.

These measures only address the reduction of the peak flow rate. It is also important to reduce the overall volume of runoff to pre-development volumes to maintain the water balance (Section 4.1). This is achieved by a range of retention measures, including:

- Seepage techniques
- Stormwater Reuse.

Guidelines for the applications of these measures are provided below.

4.6.2. Piped Drainage Guidelines

Piped drainage is to comply with Council's design requirements for urban stormwater as detailed in Council's Draft Engineering Development Control Plan (DCP). All pits and entry points are to be labelled to indicate that runoff entering the structure will drain to a nominated watercourse or creek.

Where possible, piped drainage is not to be duplicated through a sector. However, as outlined in Section 4.3, some Sectors do drain areas that are already developed and will require either a duplicate system to convey flow through the Sector to the creek or should connect to the Sector drainage. However, in the case of connecting into the Sector drainage, consideration must be made of the additional catchment area contributing to the water quality control features installed within the Sector. Pipes are to be sized to carry the design flow indicated in Council's DCP outlined above with appropriate overland flow paths to carry flows greater than the design flow.

4.6.3. On-Site Detention Requirements

Detention requirements have been determined on a sector by sector basis, since the hydrological characteristics of each sector vary considerably across the Valley. A RAFTS model of the Valley was utilised to consider the pre-development and post-development hydrology of each sector and the overall Valley. Full details of the modelling and derivation of the on-site detention requirements can be found in Appendix A

The requirements for each sector include (Appendix A):

- Minimum site storage requirements (SSR) listed in Table A.1
- Permissible site discharges not to be greater than those listed in Table A.2 for all storm events listed
- Maintenance of the base case hydrograph shape
- Use of the Australian Rainfall and Runoff Method (1987) to determine compliance with the requirements.

During the preparation of the Water Management Report for the sector a model is to be established that:

- matches the peak sector outflow discharge to the pre-development condition of the sector within ± 5% of the peak reported in Appendix A
- shows the pre-development hydrograph and the developed hydrograph with the tail cut at the duration of the storm
- the developed hydrograph is to be no more than ± 10% of the pre-development hydrograph at any location on the rising or falling limb.

All stormwater volume control structures and detention basins are to be above the 1%AEP flood levels. (Note that Water Quality control ponds can be below the 1%AEP flood level, but are to be above the 20%AEP flood level but wholly within the private buffer zone - See Section 4.5, Table 4.3 and Section 4.3.2).

Procedures for the design of detention are to be in accordance with Council's engineering DCP and Australian Rainfall and Runoff (1987, 1998, 1999).

4.6.4. Retention Requirements

As described above, a second objective is to keep the total volume of runoff after development as close to pre-development levels as possible, in order to keep the overall water balance to a similar level (See also Section 4.1).

Retention systems are required since detention systems alone have the effect of storing runoff and releasing it at a rate no greater than the pre-development peak discharge. This means that the flows are released for a longer period of time. Degradation of the channel systems can occur due to the longer high flows, particularly flows at bankfull level, which is where the majority of erosion occurs.

Retention systems are to be incorporated as described below.

Seepage Techniques

The impact of frequent floods can be controlled by minimising the volume of runoff from these smaller storm events. This can be achieved by infiltration.

A number of potential techniques range from allotment-based techniques to those incorporated within the stormwater drainage system, including:

- infiltration trenches, pits, wells and soakaways for infiltration of roof runoff, either on an individual or multiple house basis
- directing roof runoff to ponding areas in back yards for infiltration
- grassed swales
- pervious stormwater pipes
- porous pavements
- infiltration trenches and basins, within the drainage system.

These systems are suitable for infiltrating 'clean runoff' (e.g. roof water or pre-treated stormwater) in areas with relatively high permeability soils. Runoff must be pre-treated to remove gross pollutants and large diameter sediment.

The potential for groundwater pollution needs to be considered by assessing the quality and quantity of infiltrating runoff against ambient groundwater conditions. Data to describe ambient groundwater conditions is collected by Applicants as part of geotechnical investigations separate to those required as part of this Specification for each sector. This data should be used to make this assessment.

The degree of infiltration that can be achieved for large and infrequent storm events will generally be minimal. Under these circumstances, retention of stormwater in wet basins and rainwater tanks is used to attenuate peak flows to minimise changes to the water balance.

Stormwater Reuse

Rainwater tanks or similar devices are to be provided for collecting roof runoff from all buildings. The water collected by these devices can be used for non-potable purposes such as garden watering. The sizing of these tanks for each lot is to be included in the water balance calculations (Section 4.1.2).

With regard to on-site detention, the tanks could be utilised for on-site detention requirements. It is possible under certain situations to combine these storages into a single structure, with a lower level reuse component and an upper level detention component. It is up to the Applicant to demonstrate the effectiveness of this approach and how it meets the dual objectives of detention and retention.

4.6.5. Reporting

The section of the Water Management Report that deals with Stormwater Quantity Management will detail how the twin objectives of maintenance of peak discharge, and the maintenance of pre- and post-development water balance are to be achieved. Stormwater quantity and quality controls provide an opportunity to provide a multi-use facility within the development area. The section of the report is to address all relevant issues in an integrated, co-ordinated plan.

On-site detention and retention storage distribution is to be determined during the design and is to be presented on the stormwater concept drainage plan. Given that Council wishes to promote the use of infiltration devices to reduce the amount of runoff water, consideration can be given to the storage effects of distributed devices such as infiltration swales, trenches or other appropriate devices to take up a portion of the above total storage requirement. In each case, detailed calculations are to be provided utilising site specific geotechnical data, supported by infiltrometer testing to justify the storage calculations (Section 4.1.1). Effective operation of these measures relies on blockage and clogging being excluded, and any design must address how gross pollutants and sediments are to be removed prior to entry to any such devices.

After the construction of detention facilities these must be inspected on a regular basis (at the same time as any stormwater quality improvement device is inspected/cleaned). Inspection reports are to be provided to Council three weeks after the inspections to certify that the facility is operating as designed or showing a corrective action has been undertaken. Details of these inspection should also be included in the three monthly reports after construction commencement.

4.7. STORMWATER DRAINAGE CONCEPT PLAN (SDCP)

All of the issues addressed in Sections 4.1 though to 4.6, are to be reported in a Stormwater Drainage Concept Plan to be submitted with the application demonstrating the feasibility of the proposed drainage system within the Sector and suitability for connection to Council's system. The details shown on this plan must be compatible with the planning requirements (e.g. landscaping and height restrictions). Early consultation between engineers and architects is required to reduce possible conflicts in the final plan. This plan is to show:

1. Location and size of all water quality devices (e.g. ponds, filter strips)
2. Location and size of detention facilities
3. 1% AEP and PMF flood extents
4. Creekline corridors
5. Piped drainage system consistent with Councils regulations and the Draft Engineering DCP
6. Retention facilities
7. Surface flowpaths
8. Any easements required
9. Site constraints (e.g. location of services, mosquito's, heritage orders, aesthetics and trees).

The application will not be accepted without such a plan. Each application must be accompanied by the associated information listed in Appendix D and Table 3.1.

4.8. WASTEWATER INFRASTRUCTURE CONSIDERATIONS

Potential conflicts between stormwater and water and wastewater infrastructure will exist, particularly along the waterway corridors. Details of existing and proposed water and wastewater infrastructure are to submitted, together with any interactions with stormwater and watercourse corridor works.

Consideration must be given to the potential risk of damage to water and wastewater pipes from tree roots, and consequent environmental impacts and maintenance costs. Planting of large species trees in Sydney Water easements is not permitted (under Section 46 of the Water Board (Corporation) Act, 1994).

Relevant requirements of Sydney Water are detailed in a number of publications, such as:

- "Sewerage Code of Australia" (Water Services Association of Australia Publication WSA 02-1999)
- "Supplement Sewerage Code of Australia" (Sydney Water)
- "Work Manual No 6" (Sydney Water, December 1999)
- "Building Over Sewers" (Sydney Water)
- "Keeping Tree Roots out of your Sewer" (Sydney Water).

Note that the *Sewerage Code of Australia* deals with:

- Design of sewerage systems – the sewer layout and the sewer connections
- Materials used in the system
- Construction of the various components of the system.

The design section of the code contains relevant information for the requirements of subdivisions and natural watercourse design.

The code outlines the areas to be avoided for sewer construction if possible which include:

- waterways and floodways;
- wetlands,
- swamps,
- estuaries,
- sand dunes, and
- foreshore areas.

If these areas cannot be avoided then very careful consideration (consultation with owners and regulatory bodies) needs to be given to the pipeline location and construction.

It is the responsibility of the Applicant to be aware of all Sydney Water Corporation requirements.

5. PRIVATE CERTIFICATION GUIDELINES

As outlined in the flow chart in Section 1.1, private certification is required for the Construction Certificate to be issued. Where certification is called for in this Specification, the Applicant shall submit to Council a certificate from a suitably qualified and experienced professional certifying the relevant section of work. Details on the requirements and accreditation for Private Certifiers can be acquired through the Institution of Engineers, Australia (July, 2000). Such certification shall be addressed to Council and is to state the purpose for which it is given, the context in which it was commissioned, and list any limitations, qualifications or reservations by the certifier. Assistance for certifiers can be found at the Department of Urban Affairs and Planning (DUAP) website which has sample forms for the Development Assessment Process.

Further details on the nature of the Development Assessment Process can be found in the DUAP publication *Guiding Development - Better Outcomes* (1999).

In order to issue a Construction Certificate, each component of the submissions at Rezoning and Development Application stage must be reviewed and certified by qualified professionals. The following are the required qualifications and expertise required for certification, details of which are to be provided to Council:

- Water Cycle Calculations and conclusions are to be reviewed and certified by an Experienced and Qualified engineering hydrologist with demonstrated expertise in water balance studies, and who is NPER accredited by the Institution of Engineers, Australia
- The Water Quality monitoring plan is to be reviewed by an independent experienced and qualified professional with demonstrated expertise in management of water quality monitoring plans.
- The effectiveness of the Water Quality devices is to be reviewed by an experienced and qualified professional who has demonstrated experience in total catchment management solutions.
- All aspects of the Water Management Report are to be reviewed by an independent experienced and qualified professional with demonstrated expertise all aspects of water management.

The Certification is to include an acknowledgement that Council will be relying on the professional advice provided.

6. SUMMARY OF RELEVANT NATURAL RESOURCE MANAGEMENT LEGISLATION

There are a number of Acts of Parliament that are relevant to the development of land. A brief description of the relevant acts is included in this Specification to alert potential Applicants to the wide range of environmental legislation that can apply to stormwater management. It is the responsibility of the Applicant to be aware of all Acts of Parliament that might impact on the development of each sector.

The following excerpts are from the EPA Council Handbook (1997) and have been updated where legislation has been amended in the period since publication, and are not intended to be a complete description of the acts. Note that each submission made by an Applicant will be circulated by Council to the relevant authorities that administer the acts where appropriate for consideration. Approvals may be required under certain legislation and it is the responsibility of the Applicant to be aware of the Approvals and Permits required from the relevant authorities.

Local authorities have the primary responsibility for managing urban stormwater in their own areas as a result of their land use e.g., development control and drainage related powers and responsibilities provided by the Environmental Planning and Assessment Act 1979 and the Local Government Act 1993.

However, various State government authorities responsible for planning, environmental protection and land and water management administer statutory controls, which can affect urban stormwater management. In addition, Sydney Water Corporation may have easements over sections of the stormwater drainage system in the area, particularly where rising mains and sewer carriers cross channels.

In December 2000, the NSW Parliament passed the *Water Management Bill* with various aspects being progressively implemented from 1 January 2001. This Act repeals or amends almost all of the legislation summarised below. Applicants are advised to consider the implications of the new Act and prepare for the transitions accordingly.

Note that repealed Acts (outlined in Schedule 7 of the Bill) include:

- *Drainage Act 1939 No 29*
- *Miscellaneous Acts (Water Administration) Amendment Act 1986 No 205*
- *Rivers and Foreshores Improvement Act 1948 No 20*
- *Water Act 1912 No 44*
- *Water (Amendment) Act 1936 No 31*
- *Water (Amendment) Act 1940 No 57*
- *Water (Amendment) Act 1976 No 33*
- *Water (Amendment) Act 1979 No 159*
- *Water (Soil Conservation) Amendment Act 1986 No 143*
- *Water Administration Act 1986 No 195.*

Prior to the adoption of the *Water Management Bill*, the following acts were relevant:

Legislation Title	Description and Administration
Catchment Management Act 1989	The Catchment Management Act 1989 provides a statutory basis for the principle of total catchment management, (TCM).
Drainage Act 1939	The Drainage Act 1939, administered by the Department of Land and Water Conservation, provides for the drainage of land, the mitigation of the effects of floods and the control of floodwaters within certain areas.
Environmental Planning and Assessment Act, 1979	The Environmental Planning and Assessment Act, 1979 (EP&A Act) establishes a system of environmental planning and assessment under the overview of the Department of Urban Affairs and Planning (DUAP) with, usually, local implementation by Councils.
Fisheries Management Act 1994	The Fisheries Management Act is administered by NSW Fisheries and includes provisions for the management of fish habitat.
Local Government Act 1993	The Local Government Act 1993, primarily administered by the Department of Local Government, gives local councils the power to control and regulate the drainage of land and to construct drains in their locality.
Noxious Weeds Act, 1993	The Noxious Weeds Act, 1993, aims to ensure appropriate measures for the control of noxious weeds throughout NSW.
Protection of the Environment Administration Act 1991	The Protection of the Environment Administration Act establishes the Environment Protection Authority (EPA).
Protection of the Environment Operations (POEO) Act 1997	Consolidates the key pollution statutes under a single Act. It replaces; the Clean Air Act 1961, the Clean Waters Act 1970, the Environmental Offences and Penalties Act 1989, the Noise Control Act 1975, the Pollution Control Act 1970, and incorporates the major regulatory provisions of the Waste Minimisation and Management Act 1995. The POEO Act enables the explicit protection of the environment policies (PEPs) and more innovative approaches to reducing pollution. The Act also provides a single licensing arrangement to replace the different licences and approvals under existing separate Acts. Integration of EPA licensing with the development approval procedures under the EP&A Act 1979 provides public participation in the environmental assessment of activities that may be licensed by the EPA.
Rivers and Foreshores Improvement Act 1948	The Rivers and Foreshores Protection Act 1948 aims to control excavations, the placement of fill and other works in or near rivers, estuaries and lakes. The Act is administered by the Department of Land and Water Conservation.

Legislation Title	Description and Administration
Soil Conservation Act 1938	The Soil Conservation Act 1938 provides for the conservation of soil resources and farm water resources and the mitigation of erosion. The Department of Land and Water Conservation administers the Act.
Water Act 1912	The Water Act provides the Department of Land and Water Conservation with powers to construct drains and raise rates.
Water Administration Act 1986	The Department of Land and Water Conservation administers under this Act to ensure that the water and related resources of the State are allocated and used in ways which are consistent with environmental requirements and provide the maximum long-term benefit for the State and for Australia. The Act ensures water and related resources are provided to meet the needs of water users in a commercial manner consistent with the overall water management policies of the Government.

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Appendix A

On-Site Detention Requirements

A1 INTRODUCTION

The need for on-site detention (OSD) results from the requirement to maintain existing peak flows so that following development flooding will not be worse than the pre-existing condition. The consequence of this requirement is that OSD is to be designed to accept a volume difference between the developed hydrograph and the pre-existing hydrograph to ensure that peak flows are not increased.

A detailed assessment of the OSD requirements was prepared and this Appendix is a summary of the detailed report (Lawson & Treloar, December 1999).

A2 ON-SITE DETENTION (OSD) CALCULATIONS

On-site detention requirements include:

- site storage requirement (SSR), and
- permissible site discharge (PSD).

A number of methods have been published for the calculation of OSD requirements. These include (Bewsher, 1993, Ribbons et al, 1995):

- Australian Rainfall and Runoff - mass curve technique
- Swinburne Method - based on the rational method, designed to limit the discharge from a site to the capacity of the downstream pipe system
- Wollongong Method - assumption of a triangular-shaped, rational-method-derived hydrograph, with volume of storage determined by calculating maximum difference between the before and after hydrographs for a range of storm duration's
- Rainfall-Runoff Models - models such as RAFTS, ILSAX or RORB to measure impacts at a number of locations throughout the catchment
- Upper Parramatta River Catchment Trust Method - requirements for the entire catchment derived from modelling of the catchment assuming small distributed storages which relates site storage volume to the permissible site discharge via a regression equation.

A sector by sector approach was adopted since the variations in sector characteristics are considerable. The blanket application of an OSD requirement outlined in the May 1999 version of this Specification has been altered for this reason.

The OSD calculations are based on the prescribed scenario of considering rural or forested conditions as the base conditions and medium density development (50% impervious surface) as the developed conditions.

The Australian Rainfall and Runoff method was used to derive the OSD requirements using a RAFTS model of the entire catchment. This method is based on a mass-curve analysis derived from “Australian Rainfall and Runoff” (1987) Technical Note 1 - Chapter 14. The concept is to compare the cumulative volume (or mass curve) of a base condition hydrograph with the cumulative volume from the developed conditions

over the duration of the hydrograph and determine the maximum difference in the volumes at any particular time during the entire duration. The base condition of the catchment was taken as rural unless there were existing forested areas in which case this condition was included in the base case consideration.

A3 Site Storage Requirement

The results of this analysis, considering sector groups (generally on a catchment basis) are provided in Table A.1.

Table A.1: Site Storage Requirements, SSR (m^3/ha) - Based on 1%AEP 1 Hour Critical Storm

Sectors	SSR (m^3/ha)
1,2,3,4,5,6,7,C,D	368
8,9	400
10	366
11,12	488
14	519
15	457

Note: Sectors 17 and B are unlikely to be further developed and have therefore been omitted.

As outlined in Section A2, the site storage requirements are based upon the assumption that the sector development will result in a total of 50% impervious area. If a sector's impervious area exceeds the 50% impervious area, a reassessment of the SSR, using the same methods outlined in this Appendix, is required based on the calculated impervious proportion of the site.

A4 Permissible Site Discharge

The permissible site discharge (PSD) derived from RAFTS modelling for all sectors is outlined in Table A.2. Any proposed on-site detention design must demonstrate that the PSD is not exceeded for all of the storm duration's listed in Table A.2.

Table A.2: Permissible Site Discharge for Base Case (Rural Conditions)

Sector	Area (ha)	1%-30min		1%-1hr		1%-2hr		1%-3hr		1%-6hr	
		Peak Q (m^3/s)	PSD (l/s/ha)	Peak Q (m^3/s)	PSD (l/s/ha)	Peak Q (m^3/s)	PSD (l/s/ha)	Peak Q (m^3/s)	PSD (l/s/ha)	Peak Q (m^3/s)	PSD (l/s/ha)
1	16.90	1.767	**105**	3.142	**186**	3.331	**197**	2.948	**174**	3.070	**182**
2	4.44	0.624	**141**	1.012	**228**	1.037	**234**	0.806	**182**	0.900	**203**
3	8.13	0.460	**57**	1.002	**123**	1.207	**148**	1.142	**140**	1.254	**154**
4	12.79	1.180	**92**	2.031	**159**	2.118	**166**	1.849	**145**	1.934	**151**
5	3.62	0.831	**229**	1.199	**331**	1.411	**390**	1.010	**279**	0.850	**235**
6	2.28	0.300	**132**	0.533	**234**	0.540	**237**	0.430	**189**	0.477	**209**
7	3.02	0.225	**75**	0.471	**156**	0.535	**177**	0.498	**165**	0.516	**171**
8	13.04	1.521	**117**	2.386	**183**	2.538	**195**	1.857	**142**	2.139	**164**
9	17.08	1.737	**102**	3.412	**200**	3.448	**202**	3.031	**177**	3.347	**196**
10	14.08	1.967	**140**	3.032	**215**	3.163	**225**	2.356	**167**	2.655	**189**
11	8.25	0.242	**29**	0.505	**61**	0.768	**93**	0.837	**101**	0.860	**104**
12	17.27	1.052	**61**	2.092	**121**	2.507	**145**	2.384	**138**	2.634	**152**
14	7.94	0.263	**33**	0.629	**79**	0.864	**109**	0.899	**113**	0.937	**118**
15	16.08	0.805	**50**	1.836	**114**	2.126	**132**	2.037	**127**	2.240	**139**
17	11.09	0.189	**17**	0.453	**41**	0.741	**67**	0.851	**77**	0.948	**85**
B	5.23	0.112	**21**	0.232	**44**	0.371	**71**	0.442	**84**	0.464	**89**
C	1.85	0.135	**73**	0.261	**141**	0.298	**161**	0.280	**151**	0.306	**165**
D	8.30	1.148	**138**	1.880	**226**	1.911	**230**	1.554	**187**	1.703	**205**

A5 Conditions to be satisfied for OSD

The on-site detention requirements for the Warriewood Valley Urban Land Releases have been evaluated on a Sector by Sector basis. The overall aim is to ensure there are no adverse impacts on adjacent or downstream properties, in particular, no adverse effects on Warriewood Square, the lower reaches of Narrabeen/Mullet Creek and the Warriewood Wetlands.

There are four conditions for on-site detention that must all be satisfied:

- Minimum site storage requirements (SSR) listed in Table A.1
- Permissible site discharges (PSD) not to be greater than those listed in Table A.2 for all storm events listed
- Maintenance of the base case hydrograph shape (i.e. no premature peak or additional lag in the hydrograph and similarly shaped rising and falling limbs)
- Use of the Australian Rainfall and Runoff Method (1987) to determine compliance with the requirements.

Parameters from the RAFTS model developed for the assessment of OSD (Lawson and Treloar, 1999) and to be utilised for the hydrograph generation are listed in Table A3.

In addition to traditional approaches to providing on-site detention (via tanks, detention basins, in parking areas or formal depression areas), this Specification identifies means of offsetting the required detention volume including:

- Seepage techniques
- Modifying the impervious proportion of the development.

Should the Applicant wish to offset the site storage requirement, or if the Applicant finds that traditional designs cannot meet the PSD requirements, then the onus is placed on the Applicant for each Sector to adequately demonstrate the amount by which the site storage requirement can be offset to achieve the permissible site discharge using other techniques. As outlined in Section 4.1, infiltrometer tests are required as part of the preparation of the Water Management Report. These tests are required in the assessment of the likely infiltration that can be achieved.

Table A3 - RAFTS Parameters for Hydrograph Generation

Sector	RAFTS Identifier	BASE CONDITION PARAMETERS								DEVELOPED CONDITION PARAMETERS							
		Area (ha) #1	Area (ha) #2	%Im #1	%Im #2	Slp % #1	Slp % #2	Pern #1	Pern #2	Area (ha) #1	Area (ha) #2	%Im #1	%Im #2	Slp % #1	Slp % #2	Pern #1	Pern #2
1	O1A	11.4	0.001	5	100	3.4	0.2	0.07	0.015	5.69	5.69	5	100	3.4	3.4	0.025	0.015
	O1B	5.4	0.001	5	100	4.4	4.4	0.07	0.015	2.72	2.72	5	100	4.4	4.4	0.025	0.015
2	O2	4.3	0.001	5	100	4.4	4.4	0.07	0.015	2.14	2.14	5	100	4.4	4.4	0.025	0.015
3	O3	8.13	0.001	5	100	1.5	1.5	0.07	0.015	4.07	4.07	5	100	1.5	1.5	0.025	0.015
4	OC11	8.5	0.001	5	100	2.6	2.6	0.05	0.015	4.25	4.25	5	100	2.6	2.6	0.025	0.015
	OC12	4.29	0.001	5	100	0.3	0.3	0.05	0.015	2.15	2.15	5	100	0.3	0.3	0.025	0.015
5	M5	2.7	0.001	5	100	5	5	0.05	0.015	1.35	1.35	5	100	5	5	0.025	0.015
	N5	0.94	0.001	5	100	17.1	17.1	0.07	0.015	0.48	0.48	5	100	17.1	17.1	0.025	0.015
6	M6	2.3	0.001	5	100	1.8	1.8	0.05	0.015	1.15	1.15	5	100	1.8	1.8	0.025	0.015
7	MA7	3	0.001	5	100	3	0.2	0.1	0.015	1.5	1.5	5	100	3	3	0.025	0.015
8	T81	5.67	0.001	5	100	9	9	0.07	0.015	2.83	2.83	5	100	9	9	0.025	0.015
	R8	2.12	0.001	5	100	15.5	15.5	0.1	0.015	1.07	1.07	5	100	15.5	15.5	0.025	0.015
	T82	5.3	0.001	5	100	0.8	0.8	0.07	0.015	2.63	2.63	5	100	0.8	0.8	0.025	0.015
9	R9	1.66	0.001	5	100	14.7	14.7	0.1	0.015	0.83	0.83	5	100	14.7	14.7	0.025	0.015
	T9	10.1	0.001	5	100	4.7	4.7	0.07	0.015	5.02	5.02	5	100	4.7	4.7	0.025	0.015
	S9	1.26	0.001	5	100	8.7	8.7	0.1	0.015	0.64	0.64	5	100	8.7	8.7	0.025	0.015
	H91	2.01	0.001	5	100	13.3	13.3	0.1	0.015	1.01	1.01	5	100	13.3	13.3	0.025	0.015
	H92	2.1	0.001	5	100	9.2	9.2	0.1	0.015	1.05	1.05	5	100	9.2	9.2	0.025	0.015
10	H10	9.51	0.001	5	100	9	9	0.07	0.015	4.75	4.75	5	100	9	9	0.025	0.015
	K10	4.84	0.001	5	100	1.3	1.3	0.07	0.015	2.42	2.42	5	100	1.3	1.3	0.025	0.015
11	T11	2.73	0.001	5	100	0.5	0.5	0.07	0.015	1.37	1.37	5	100	0.5	0.5	0.025	0.015
	K11	5.6	0.001	5	100	0.4	0.4	0.07	0.015	2.79	2.79	5	100	0.4	0.4	0.025	0.015
12	T12	0.88	0.001	5	100	2.7	2.7	0.07	0.015	0.45	0.45	5	100	2.7	2.7	0.025	0.015
	K121	9.09	0.001	5	100	1.5	1.5	0.07	0.015	4.55	4.55	5	100	1.5	1.5	0.025	0.015
	K122	7.27	0.001	5	100	1.4	1.4	0.07	0.015	3.64	3.64	5	100	1.4	1.4	0.025	0.015
14	K13	7.9	0.001	5	100	1.4	1.4	0.1	0.015	3.95	3.95	5	100	1.4	1.4	0.025	0.015
15	K151	3.53	0.001	5	100	0.9	0.9	0.05	0.015	1.77	1.77	5	100	0.9	0.9	0.025	0.015
	K152	7.16	0.001	5	100	0.9	0.9	0.05	0.015	3.58	3.58	5	100	0.9	0.9	0.025	0.015
	K153	5.39	0.001	5	100	0.9	0.9	0.05	0.015	2.7	2.7	5	100	0.9	0.9	0.025	0.015
17	Q11	11.09	0.001	5	100	0.2	0.2	0.05	0.015	8.87	2.2	5	100	0.2	0.2	0.05	0.015
B	Q13	5.23	0.001	5	100	0.3	0.3	0.07	0.015	5.23	0.001	5	100	0.3	0.3	0.07	0.015
C	OC14	1.85	0.001	5	100	0.6	0.6	0.05	0.015	0.93	0.93	5	100	0.6	0.6	0.025	0.015
D	OC13	8.3	0.001	5	100	7.1	7.1	0.05	0.015	4.15	4.15	5	100	7.1	7.1	0.025	0.015

A6 Sector 12 and 14 Considerations

Some parts of sectors 12 and 14 discharge directly to the Warriewood Wetlands. For these areas ONLY, the Applicant may submit details for reduced on-site detention facilities if the following criteria can be fulfilled:

- No adverse water level impacts on the properties surrounding the wetlands
- No ecological impacts on the Warriewood Wetlands and
- No impacts on the overland flow paths between the sectors and the wetlands.

A7 Considerations for Areas Affected by the 1%AEP Flood

Some sectors within the lower end of the Valley currently have a substantial portion of the sector affected by the 1%AEP flood extent (for example, Sectors 15, 17 and B).

Within these sectors OSD for the 1%AEP is not required for the portion of land that is flood affected. However, in these areas OSD is required for more frequently occurring events such as the 5%AEP and the 20%AEP.

Details of the SSR and PSD for these events have not been included in this Specification and can be made available on request from Council to Applicants for these sectors.

Appendix B

PEAK FLOW RATES AT UPSTREAM AND DOWNSTREAM ENDS OF EACH SECTOR

B1 Overview

The design of the creekline corridor requires the dual consideration of both environmental flow conveyance and flood flow conveyance. Section 4.4 of the Specification outlines in detail the requirements for creekline corridor design.

B2 Design Guidance

To assist Applicants with preparing the cross sections for the creekline corridor design, peak discharge rates based on the 'base' or 'rural/forested' condition outlined for the on-site detention requirements (Appendix A) are provided in Table B1. These values have been derived from the RAFTS model prepared for the entire Valley for the critical storm duration for the Valley of two hours (described in Appendix A). The parameters used in the RAFTS model to generate these flows are listed in Table A3.

Table B1 shows, for each sector, the peak discharge at the upstream and downstream ends of the sector for the PMF, 1%AEP, 2%AEP, 5%AEP, 20%AEP and the 50%AEP. The table shows the associated creek which the sector drains to, or if the sector does not wholly drain to one creek, then the area/sector the sector drains to. The table also shows where any sectors share the same portion of a creek.

B3 Interim Conditions

Interim creekline corridor designs will also need to consider peak flows under existing conditions since the peak flows for the design condition assume that on-site detention will be provided for in each sector in the quantities outlined in Appendix A.

Table B1 Peak Flow Rates at Upstream and Downstream Ends of Each Sector (2 Hour Storm)

Sector	PMF		1% AEP		2% AEP		5% AEP		20% AEP		50%AEP		Creek	Other Sectors Sharing this portion of Creek	Comment
	u/s (m^3/s)	d/s (m^3/s)	u/s (m^3/s)	d/s (m^3/s)	u/s (m^3/s)	d/s (m^3/s)	u/s (m^3/s)	d/s (m^3/s)	u/s (m^3/s)	d/s (m^3/s)	u/s (m^3/s)	d/s (m^3/s)			
1	122.3	149.6	27.0	33.5	22.2	27.4	16.5	20.5	8.6	10.8	3.3	4.6	Narrabeen	3	Shared also with Stage 1 Release area.
2	149.6	163.7	33.5	36.5	27.4	29.7	20.5	22.2	10.8	11.8	4.6	5.1	Narrabeen	3	
3	138.7	163.7	31.0	36.5	25.3	29.7	19.0	22.2	10.0	11.8	4.1	5.1	Narrabeen	1, 2	
4	163.7	180.5	36.5	40.0	19.7	32.3	22.2	24.1	11.7	12.8	5.1	5.7	Narrabeen	C	
5	62.8	75.0	14.1	17.0	11.5	13.6	8.6	10.1	4.2	5.0	1.3	1.5	Narrabeen	6	
6	62.8	75.0	14.1	17.0	11.5	13.6	8.6	10.1	4.2	5.0	1.3	1.5	Narrabeen	5	
7	4.8	7.1	1.03	1.53	0.82	1.27	0.61	0.94	0.28	0.47	0.04	0.12	Narrabeen	None	Sector lies well away from the edge of the creek and will not require creekline corridor design in the same manner as other sectors.
8	19.8	51.5	3.8	10.5	3.1	8.3	2.2	6.1	1.0	3.0	0.15	0.78	Fern	9	
9	19.8	51.5	3.8	10.5	3.1	8.3	2.2	6.1	1.0	3.0	0.15	0.78	Fern	8	A portion of Sector 9 drains to Sector 12 before discharge to the Warriewood Wetlands
10	3.20 1.95	17.8	0.71 0.42	4.20	0.52 0.32	3.27	0.39 0.24	2.41	0.19 0.12	1.23	0.03 0.02	0.60	Mullet		Adjacent to Mullet Creek. Stormwater drainage on existing site to both Mullet Creek and Sector 12. Two values in table reflect flow comes from two branches (north and west).
11	51.5	55.5	10.5	11.1	8.3	8.9	6.1	6.5	3.0	3.3	0.78	0.90	Fern	12	Fern Creek flows into Warriewood Wetlands
12	51.5	55.5	10.5	11.1	8.3	8.9	6.1	6.5	3.0	3.3	0.78	0.90	Fern	11	Fern Creek flows into Warriewood Wetlands
14	55.5	57.8	11.1	11.6	8.9	9.2	6.5	6.8	3.2	3.4	0.90	0.97	Fern	None	Fern Creek flows into Warriewood Wetlands
15E	193.5	218.3	42.2	46.6	34.5	38.1	25.6	28.2	13.5	15.1	6.2	7.1	Narrabeen	17, B	The eastern portion of Sector 15 (defined by Boondah Road in the middle of the sector) drains to Narrabeen Creek.
15W	0.0	7.3	0.00	0.76	0.00	0.64	0.00	0.53	0.00	0.39	0.00	0.16	Wetlands	None	The western portion of Sector 15 (defined by Boondah Road) does not drain to Narrabeen Creek, but drains directly to the Warriewood wetlands.
17	193.5	215.0	42.2	46.1	34.5	37.7	25.6	27.9	13.5	14.9	6.2	7.0	Narrabeen	15	
B	215.0	218.3	46.1	46.6	37.7	38.1	27.9	28.2	14.9	15.1	7.0	7.1	Narrabeen	15	This portion of the creek recently rehabilitated by Council under the Commonwealth Coast and Clean Seas Project.
C	165.8	180.5	36.6	39.6	39.9	32.3	22.3	24.1	11.8	12.8	5.1	5.7	Narrabeen	4	Portion of flow split to existing floodway through Sector D not considered.
D	180.5	193.5	39.6	42.2	32.3	34.5	24.1	25.6	12.8	13.5	5.7	6.2	Narrabeen	None	As for Sector C.

Appendix C

WATER QUALITY MONITORING REQUIREMENTS AND ACCEPTANCE CRITERIA

C1 Introduction

Water quality requirements for the study area have been developed based on short-term, medium-term and long-term scenarios. 'Short-term' relates to the period during and just after development (up to 'Handover'). 'Medium-term' is the period of one year after completion of all water quality controls associated with the fully developed area. Due to the likely fragmented nature of development, permanent water quality controls may not be fully functional for some years. 'Long-term' is defined as the period after control measures are introduced for all pollutant sources in the valley.

Key areas targeted are:

- Warriewood Wetlands
- Creek Systems (water and sediment)
- Site Discharges.

The ultimate receiving water for these systems is Narrabeen Lagoon.

C2 Monitoring Requirements

Table C1 summarises the water quality monitoring requirements for various stages of the approval process for the Valley.

These requirements are to be read in conjunction with Section 4.2 of this report.

Monitoring is required at a number of locations as well as varying frequencies. Locations include at the upstream end of each sector, 'upstream', the downstream end of each sector, 'downstream', within each sector, 'in-sector', at erosion and sediment control devices, ESC' and at inlets and outlets of stormwater quality improvement devices 'SQID'. As outlined in Section 4.2.1, in-sector monitoring should occur on a major sector drainage line leading to the creek as a minimum and where significant portions of the Sector (i.e. greater than 20% of the sector) do not discharge into one of the three main creeks, monitoring must be undertaken for these areas. This may mean that an area is set aside, shaped and equipped accordingly within the sector for this purpose.

Table C1 Summary of Monitoring Requirements

Media	State	Variable	Undeveloped*		Construction Phase**		Post-Construction Phase ***	
			Wet Weather	Dry Weather	Wet Weather	Dry Weather	Wet Weather	Dry Weather
Water	Physical	Visual	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Salinity	U/D	**U/D**	U/D	**U/D**	U/D	**U/D**
		pH (Field)	U/D	**U/D**	U/D	**U/D**	U/D	**U/D**
		Temperature (Field)	U/D	**U/D**	U/D	**U/D**	U/D	**U/D**
		Dissolved Oxygen (Field)	U/D	**U/D**	U/D	**U/D**	U/D	**U/D**
		Turbidity (Field)	U/D	**U/D**	U/D	**U/D**	U/D	**U/D**
		Suspended Solids	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Volume Gross Pollutants Removed	NA	NA	NA	**SQID**	NA	**SQID**
	Chemical	Total Nitrogen	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Ammonia-Nitrogen	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Total Kjeldahl Nitrogen	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Nitrates and Nitrites	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Total Phosphorous	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Ortho-Phosphate	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Non-Filterable Phosphorous	U/D/I	**U/D/I**	U/D/I/ESC	**U/D/I**	U/D/I/SQID	**U/D/I**
		Hardness ($CaCO_3$)	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Chromium	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Lead	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Zinc	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Arsenic	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Mercury	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Copper	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Phenolic Compounds	NA	**U/D**	NA	**U/D**	NA	**U/D**
		OC/OP Pesticides	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Oil & Grease (H.E.M)	NA	**U/D**	NA	**U/D**	NA	**U/D**
		PAH	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Chlorophyll-a	NA	NA	NA	NA	NA	**U/D**
	Biological	Algal Identification and Count	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Faecal Coliform Count	U/D/I	**U/D/I**	U/D/I	**U/D/I**	U/D/I/SQID	**U/D/I**
		Biotic Index (SIGNAL)	NA	**U/D**	NA	**U/D**	NA	**U/D**
Sediment	Chemical	Chromium	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Lead	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Zinc	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Arsenic	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Mercury	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Copper	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Phenolic Compounds	NA	**U/D**	NA	**U/D**	NA	**U/D**
		Organochlorine Pesticides	NA	**U/D**	NA	**U/D**	NA	**U/D**
		PAH	NA	**U/D**	NA	**U/D**	NA	**U/D**

***Up to Construction Certificate Issue**
****Immediately after site works commence and up to Subdivision Certificate Issue**
*****Immediately after Subdivision Certificate Issue and up to Handover**

KEY for Table C1:

Frequency of Sampling	
	Annual Sampling including at least one sampling at the Rezoning stage and one sampling at the Handover stage
	Three Monthly
	Three Times Each Year, One Sample on Rising Limb and One Sample on the Falling Limb of the Hydrograph at Each Site
Location of Sampling	
U	Upstream
D	Downstream
I	In-Sector
ESC	Sediment Control Basins, Visual Inspection of other Erosion and Sediment Control Measures
SQID	GPTs, Water Quality Control Ponds and Constructed Wetlands (Inflow and Outflow Locations). Note chemical parameters not required for GPTs.
NA	Not Applicable

C3 Acceptance Criteria

Monitoring data need to be compared with various acceptance criteria listed in Table C2 at the following locations:

- Site discharges/in-sector monitoring
- Water quality and biotic index at the upstream and downstream monitoring locations
- Sediment Quality at the upstream and downstream monitoring locations.

If the acceptance criteria are exceeded, corrective action is to be undertaken.

Physico-Chemical and Faecal Coliform Sampling Compliance

Although the objectives listed in Table C2 have been developed in terms of trigger values (ANZECC, 1999), they are to be applied within a statistical context (percent compliance). In the long-term, a compliance rate of 90% with listed guidelines is to be targeted. Medium-term targets compliance is to be 90%. In the short-term, maintenance of existing conditions ('status quo') is required (i.e. 90% compliance with the median values from pre-development monitoring data). This approach allows for a statistical treatment of monitoring data and allows for occasional exceedances in parameters. For the purposes of Water Management Reporting, definitions of short-term, medium-term and long-term are provided in Section C1 and the Glossary.

With regard to metals, interpretation of results is required with details of the water hardness.

With regard to ammonia, the ANZECC guidelines set a level with respect to the in-situ concentration which is dependent on the temperature and pH of the flow. As a result, some interpretation of the laboratory data is required.

Ammonia exists in natural waters in two forms; dissolved ammonia gas (un-ionised ammonia, NH_3) and ammonium ion (dissociated ammonia, NH_4^+), total ammonia is the sum of these two forms. The ammonium ion is a nutrient source and is absorbed by plants, however un-ionised ammonia is toxic to plants. The relationship between

these forms is governed by an equilibrium reaction that is highly sensitive to pH and temperature:

$$NH_4^+ \rightarrow NH_3 + H^+$$

High pHs and high temperatures lead to higher levels of NH_3, and this is the form that dictates the toxicity of ammonia in natural waters.

In general, laboratory analysis provides data on the total ammonia in samples collected, i.e. the total of both dissolved NH_3 and NH_4^+. Hence the level of un-ionised ammonia is interpreted for the in-situ conditions. For example, the temperature and pH of a creek from which a sample was taken at the same time was measured in-situ as being 16.2°C and pH = 6.7 and the laboratory analysis returned a total ammonia concentration of 0.10 mg/L. Referring to the ANZECC (1999) guidelines indicates that the inferred un-ionised ammonia is therefore 0.00015 mg/L which is less than the trigger level for the same pH and temperature being 0.0027 mg/L (corresponding to a total ammonia concentration of 0.58 mg/L). Thus the level does not exceed the ANZECC guideline and is therefore acceptable.

Rapid Biological Assessment Compliance

Compliance with the guidelines set for the SIGNAL index is an absolute compliance.

Sediment Quality Compliance

The same comments for physico-chemical sampling compliance apply to the sediment quality.

Table C2 Summary of Acceptance Criteria - Site Discharge and Creeks

Media	State	Variable	Units	During Construction Site Discharges/Insector	Post Construction Site Discharges	Instream Short Term (Status Quo)	In-Stream Medium Term	In-Stream Long Term
Water	Physical	Visual	-	No litter	No litter	No litter	No litter	No litter
		Salinity (TDS)	mg/L	NA	NA	1000	1000	1000
		pH (Field)	-	NA	NA	6.6 - 8	6.6 - 8	6.6 - 8
		Temperature (Field)	°C	NA	NA	Status quo	Status quo	Status quo
		Dissolved Oxygen (Field)	%Sat	NA	NA	Status quo	90	90
		Turbidity (Field)	NTU	NA	NA	Status quo	50	20
		Suspended Solids	mg/L	100	50	Status quo	20	6
		Volume Gross Pollutants Removed	Tonne	NA	NA	NA	NA	NA
	Chemical	Total Nitrogen	mg/L	1.6	1.6	Status quo	1.6	1.0
		Ammonia-Nitrogen	mg/L	See Key	See Key	See Key	See Key	See Key
		Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-
		Nitrates and Nitrites	mg/L	-	-	-	-	-
		Total Phosphorous	mg/L	0.1	0.05	Status quo	0.1	0.04
		Ortho-Phosphate	mg/L	-	-	-	-	-
		Non-Filterable Phosphorous	mg/L	-	-	-	-	-
		Hardness ($CaCO_3$)	mg/L	NA	NA	-	-	-
		Chromium	mg/L	NA	NA	Status quo	50% status quo	10
		Lead	mg/L	NA	NA	Status quo	50% status quo	1
		Zinc	mg/L	NA	NA	Status quo	50% status quo	50
		Arsenic	mg/L	NA	NA	Status quo	50% status quo	50
		Mercury	mg/L	NA	NA	Status quo	50% status quo	0.1
		Copper	mg/L	NA	NA	Status quo	50% status quo	2
		Phenolic Compounds	mg/L	NA	NA	Status quo	50% status quo	Note
		OC/OP Pesticides	ng/L	NA	NA	Status quo	50% status quo	Note
		Oil & Grease (H.E.M)	mg/L	NA	NA	50	20	5
		PAH	mg/L	NA	NA	Status quo	50% status quo	3
		Chlorophyll-a	mg/m^3	NA	NA	15	15	10
	Biological	Algal Identification and Count	-	NA	NA	Status quo	No algal bloom	No algal bloom
		Faecal Coliform Count	Cfu/ 100mL	150	150	1000	150	150
		Biotic Index (SIGNAL)	-	NA	NA	Status quo	> 5	> 6
Sediment	Chemical	Chromium	mg/kg	NA	NA	Status quo	50% status quo	80
		Lead	mg/kg	NA	NA	Status quo	50% status quo	50
		Zinc	mg/kg	NA	NA	Status quo	50% status quo	200
		Arsenic	mg/kg	NA	NA	Status quo	50% status quo	20
		Mercury	mg/kg	NA	NA	Status quo	50% status quo	0.15
		Copper	mg/kg	NA	NA	Status quo	50% status quo	65
		Phenolic Compounds	mg/kg	NA	NA	Status quo	50% status quo	Note
		Organochlorine Pesticides	mg/kg	NA	NA	Status quo	50% status quo	Note
		Total PAH	mg/kg	NA	NA	Status quo	50% status quo	4000

NOTES and KEY for Table C2:

Definitions of 'Short-term', 'Medium-term' and 'Long-term' are provided in Section C1
'Status Quo' means the median value is within the range of the 10%ile and 90%ile from the pre-development condition data
50% Status Quo means the median value is within the range of 50% of the 10%ile and 50% of the 90%ile from the pre-development condition data
Sediment guidelines are dry weight from ANZECC, 1999
General values have been adopted with consideration of ANZECC 1999, ANZECC, 1992, Brisbane City Council, 2000, Lawson & Treloar, 1997 and Laxton, 1993
TDS values are appropriate for non-tidal sections of the creeks only
Water Hardness required to assist with interpretation of ANZECC, 1999 trigger guidelines for metal concentrations
For the purposes of comparing the results with ANZECC, 1999 guidelines, the creeks can generally be defined as 'lowland rivers'
If the existing level is lower than the medium or long-term guideline provided, the existing level is not to be exceeded
Note - ANZECC 1999 guidelines for each compound to be used
Ammonia - Details for the assessment of ammonia are described in Section C3. Comparison required with ANZECC (1999) guidelines for all samples.

Appendix D

DOCUMENTATION CHECKLISTS TO BE ATTACHED WITH RELEVANT APPLICATIONS

DOCUMENTATION CHECKLIST - REZONING

(Detach and include with submissions)

Section	Item	Requirement	Check (Ö)
4.1	Water Cycle Assessment - Water Balance Modelling Pre & Post Development		
4.1.1	Stream Gauging, infiltration testing and use of local rainfall data for modelling	♦♦♦♦♦♦♦♦	
4.2.1	Water Quality Monitoring Plan	♦♦♦♦♦♦♦♦	
4.2.1	Water Quality Monitoring Sites Shown on Plan (at least three)	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Water Quality Monitoring Data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data from SQID's		
4.3	Water Quality Management Assessment - Load Modelling Pre and Post Development		
4.3.1, 3	Justification of assumptions for Event Mean Concentrations	♦♦♦♦♦♦♦♦	
4.3.2	Identification of and details for Stormwater quality facilities		
4.3.2, 4.4.5	Mosquito Risk Assessment for both Watercourse and Water Quality/Quantity features		
4.3.6, 4.6.5	Inspection and Cleaning Reports for SQID's and OSD		
4.3.5	Environmental Management Plan (Soil and Water Aspects)		
4.3.4	Erosion and Sediment Control Plan		
4.3.6	Management Plan for Stormwater Quality Improvement Devices		
4.4.3, 4, 5	Existing and Proposed Creek Corridor in plan with cross/long sections with flood levels		
4.4.4	Proposed Creek Corridor Planting Schedule		
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan		
4.4.5	Vegetation and Creek Maintenance and Monitoring Reports		
4.5	Flood Analysis – existing and design conditions		
4.5.2	Compliance of structures and creek corridor with flood planning levels		
4.5.4	Details of Interim Flood Protection Works		
4.6.3	Design Storm Hydrological Modelling of Site - Pre and Post Development		
4.6.3	On-Site Detention Facilities		
4.6.4	Stormwater Retention Facilities		
4.7	Stormwater Concept Drainage Plan		

KEY:

	Preliminary Calculations/Assessment Required		*Work as Executed Plans*
	Concept Design Required	♦♦♦♦♦♦	*Required/Reviewed/Updated*
+++++++	*Detailed Assessment/Calculations/Design*		*Not required*

Note 1 Even if the works are not to be constructed by the Applicant on the land to be transferred to Council under the Material Public Benefit Option in the Section 94 Plan, preliminary investigation for Rezoning and concept design at DA stage is required

Completed by Principal Certifier:

Name:..... _____
Title:..... _____
Organisation: ..... _____

Signature: ..... _____
Date:..... _____

DOCUMENTATION CHECKLIST - DEVELOPMENT APPLICATION

(Detach and include with submissions)

Section	Item	Requirement	Check (Ö)
4.1	Water Cycle Assessment - Water Balance Modelling Pre & Post Development	++++++++++	
4.1.1	Stream Gauging, infiltration testing and use of local rainfall data for modelling	♦♦♦♦♦♦♦♦	
4.2.1	Water Quality Monitoring Plan	♦♦♦♦♦♦♦♦	
4.2.1	Water Quality Monitoring Sites Shown on Plan (at least three)	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Water Quality Monitoring Data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data from SQID's		
4.3	Water Quality Management Assessment - Load Modelling Pre and Post Development	++++++++++	
4.3.1, 3	Justification of assumptions for Event Mean Concentrations	♦♦♦♦♦♦♦♦	
4.3.2	Identification of and details for Stormwater quality facilities		
4.3.2, 4.4.5	Mosquito Risk Assessment for both Watercourse and Water Quality/Quantity features	♦♦♦♦♦♦♦♦	
4.3.6, 4.6.5	Inspection and Cleaning Reports for SQID's and OSD		
4.3.6	Management Plan for Stormwater Quality Improvement Devices	♦♦♦♦♦♦♦♦	
4.3.5	Environmental Management Plan (Soil and Water Aspects)		
4.3.4	Erosion and Sediment Control Plan		
4.4.3, 4, 5	Existing and Proposed Creek Corridor in plan with cross/long sections with flood levels	♦♦Note 1♦♦	
4.4.4	Proposed Creek Corridor Planting Schedule	Note 1	
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan	Note 1	
4.4.5	Vegetation and Creek Maintenance and Monitoring Reports		
4.5	Flood Analysis – existing and design conditions		
4.5.2	Compliance of structures and creek corridor with flood planning levels		
4.5.4	Details of Interim Flood Protection Works		
4.6.3	Design Storm Hydrological Modelling of Site - Pre and Post Development	++++++++++	
4.6.3	On-Site Detention Facilities		
4.6.4	Stormwater Retention Facilities		
4.7	Stormwater Concept Drainage Plan	♦♦♦♦♦♦♦♦	

KEY:

	Preliminary Calculations/Assessment Required		*Work as Executed Plans*
	Concept Design Required	♦♦♦♦♦♦	*Required/Reviewed/Updated*
+++++++	*Detailed Assessment/Calculations/Design*		*Not required*

Note 1 Even if the works are not to be constructed by the Applicant on the land to be transferred to Council under the Material Public Benefit Option in the Section 94 Plan, preliminary investigation for Rezoning and concept design at DA stage is required

Completed by Principal Certifier:

Name:..... _____
Title:..... _____
Organisation: ..... _____

Signature: ..... _____
Date:..... _____

DOCUMENTATION CHECKLIST - CONSTRUCTION CERTIFICATE

(Detach and include with submissions)

Section	Item	Requirement	Check (Ö)
4.1	Water Cycle Assessment - Water Balance Modelling Pre & Post Development		
4.1.1	Stream Gauging, infiltration testing and use of local rainfall data for modelling		
4.2.1	Water Quality Monitoring Plan	♦♦♦♦♦♦♦♦	
4.2.1	Water Quality Monitoring Sites Shown on Plan (at least three)	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Water Quality Monitoring Data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data from SQID's		
4.3	Water Quality Management Assessment - Load Modelling Pre and Post Development		
4.3.1, 3	Justification of assumptions for Event Mean Concentrations		
4.3.2	Identification of and details for Stormwater quality facilities	++++++++++	
4.3.2, 4.4.5	Mosquito Risk Assessment for both Watercourse and Water Quality/Quantity features	++++++++++	
4.3.6, 4.6.5	Inspection and Cleaning Reports for SQID's and OSD		
4.3.6	Management Plan for Stormwater Quality Improvement Devices	++++++++++	
4.3.5	Environmental Management Plan (Soil and Water Aspects)	++++++++++	
4.3.4	Erosion and Sediment Control Plan	++++++++++	
4.4.3, 4, 5	Existing and Proposed Creek Corridor in plan with cross/long sections with flood levels	+++Note 1+++	
4.4.4	Proposed Creek Corridor Planting Schedule	+++Note 1+++	
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan	♦♦Note 1♦♦	
4.4.5	Vegetation and Creek Maintenance and Monitoring Reports		
4.5	Flood Analysis – existing design conditions	♦♦♦♦♦♦♦♦	
4.5.2	Compliance of structures and creek corridor with flood planning levels	++++++++++	
4.5.4	Details of Interim Flood Protection Works	++++++++++	
4.6.3	Design Storm Hydrological Modelling of Site - Pre and Post Development	♦♦♦♦♦♦♦♦	
4.6.3	On-Site Detention Facilities	++++++++++	
4.6.4	Stormwater Retention Facilities	++++++++++	
4.7	Stormwater Concept Drainage Plan		

KEY:

	Preliminary Calculations/Assessment Required		*Work as Executed Plans*
	Concept Design Required	♦♦♦♦♦♦	*Required/Reviewed/Updated*
+++++++	*Detailed Assessment/Calculations/Design*		*Not required*

Note 1 Even if the works are not to be constructed by the Applicant on the land to be transferred to Council under the Material Public Benefit Option in the Section 94 Plan, preliminary investigation for Rezoning and concept design at DA stage is required

Completed by Principal Certifier:

Name:..... _____
Title:..... _____
Organisation: ..... _____

Signature: ..... _____
Date:..... _____

DOCUMENTATION CHECKLIST - SUBDIVISION CERTIFICATE

(Detach and include with submissions)

Section	Item	Requirement	Check (Ö)
4.1	Water Cycle Assessment - Water Balance Modelling Pre & Post Development		
4.1.1	Stream Gauging, infiltration testing and use of local rainfall data for modelling		
4.2.1	Water Quality Monitoring Plan	♦♦♦♦♦♦♦♦	
4.2.1	Water Quality Monitoring Sites Shown on Plan (at least three)	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Water Quality Monitoring Data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data from SQID's	♦♦♦♦♦♦♦♦	
4.3	Water Quality Management Assessment - Load Modelling Pre and Post Development		
4.3.1, 3	Justification of assumptions for Event Mean Concentrations		
4.3.2	Identification of and details for Stormwater quality facilities		
4.3.2, 4.4.5	Mosquito Risk Assessment for both Watercourse and Water Quality/Quantity features	♦♦♦♦♦♦♦♦	
4.3.6, 4.6.5	Inspection and Cleaning Reports for SQID's and OSD		
4.3.6	Management Plan for Stormwater Quality Improvement Devices	♦♦♦♦♦♦♦♦	
4.3.5	Environmental Management Plan (Soil and Water Aspects)	♦♦♦♦♦♦♦♦	
4.3.4	Erosion and Sediment Control Plan	♦♦♦♦♦♦♦♦	
4.4.3, 4, 5	Existing and Proposed Creek Corridor in plan with cross/long sections with flood levels	Note 1	
4.4.4	Proposed Creek Corridor Planting Schedule	Note 1	
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan	♦♦Note 1♦♦	
4.4.5	Vegetation and Creek Maintenance and Monitoring Reports		
4.5	Flood Analysis – existing and design conditions	♦♦♦♦♦♦♦♦	
4.5.2	Compliance of structures and creek corridor with flood planning levels		
4.5.4	Details of Interim Flood Protection Works		
4.6.3	Design Storm Hydrological Modelling of Site - Pre and Post Development	♦♦♦♦♦♦♦♦	
4.6.3	On-Site Detention Facilities		
4.6.4	Stormwater Retention Facilities		
4.7	Stormwater Concept Drainage Plan		

KEY:

	Preliminary Calculations/Assessment Required		*Work as Executed Plans*
	Concept Design Required	♦♦♦♦♦♦	*Required/Reviewed/Updated*
+++++++	*Detailed Assessment/Calculations/Design*		*Not required*

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Completed by Principal Certifier:

Name:..... _____
Title:..... _____
Organisation: ..... _____

Signature: ..... _____
Date:..... _____

DOCUMENTATION CHECKLIST - HANDOVER

(Detach and include with submissions)

Section	Item	Requirement	Check (Ö)
4.1	Water Cycle Assessment - Water Balance Modelling Pre & Post Development		
4.1.1	Stream Gauging, infiltration testing and use of local rainfall data for modelling		
4.2.1	Water Quality Monitoring Plan	♦♦♦♦♦♦♦♦	
4.2.1	Water Quality Monitoring Sites Shown on Plan (at least three)	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Water Quality Monitoring Data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data	♦♦♦♦♦♦♦♦	
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data from SQID's	♦♦♦♦♦♦♦♦	
4.3	Water Quality Management Assessment - Load Modelling Pre and Post Development		
4.3.1, 3	Justification of assumptions for Event Mean Concentrations		
4.3.2	Identification of and details for Stormwater quality facilities		
4.3.2, 4.4.5	Mosquito Risk Assessment for both Watercourse and Water Quality/Quantity features	♦♦♦♦♦♦♦♦	
4.3.6, 4.6.5	Inspection and Cleaning Reports for SQID's and OSD	♦♦♦♦♦♦♦♦	
4.3.6	Management Plan for Stormwater Quality Improvement Devices	♦♦♦♦♦♦♦♦	
4.3.5	Environmental Management Plan (Soil and Water Aspects)		
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4.4.3, 4, 5	Existing and Proposed Creek Corridor in plan with cross/long sections with flood levels		
4.4.4	Proposed Creek Corridor Planting Schedule		
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan	♦♦Note 1♦♦	
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4.5	Flood Analysis – existing and design conditions		
4.5.2	Compliance of structures and creek corridor with flood planning levels		
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4.6.3	Design Storm Hydrological Modelling of Site - Pre and Post Development		
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4.7	Stormwater Concept Drainage Plan		

KEY:

	Preliminary Calculations/Assessment Required		*Work as Executed Plans*
	Concept Design Required	♦♦♦♦♦♦	*Required/Reviewed/Updated*
+++++++	*Detailed Assessment/Calculations/Design*		*Not required*

Note 1 Even if the works are not to be constructed by the Applicant on the land to be transferred to Council under the Material Public Benefit Option in the Section 94 Plan, preliminary investigation for Rezoning and concept design at DA stage is required

Completed by Principal Certifier:

Name: ..... _____
Title: ..... _____
Organisation: ..... _____

Signature: ..... _____
Date: ..... _____