MUDGEE AND GULGONG

URBAN STORMWATER MANAGEMENT PLAN

2001

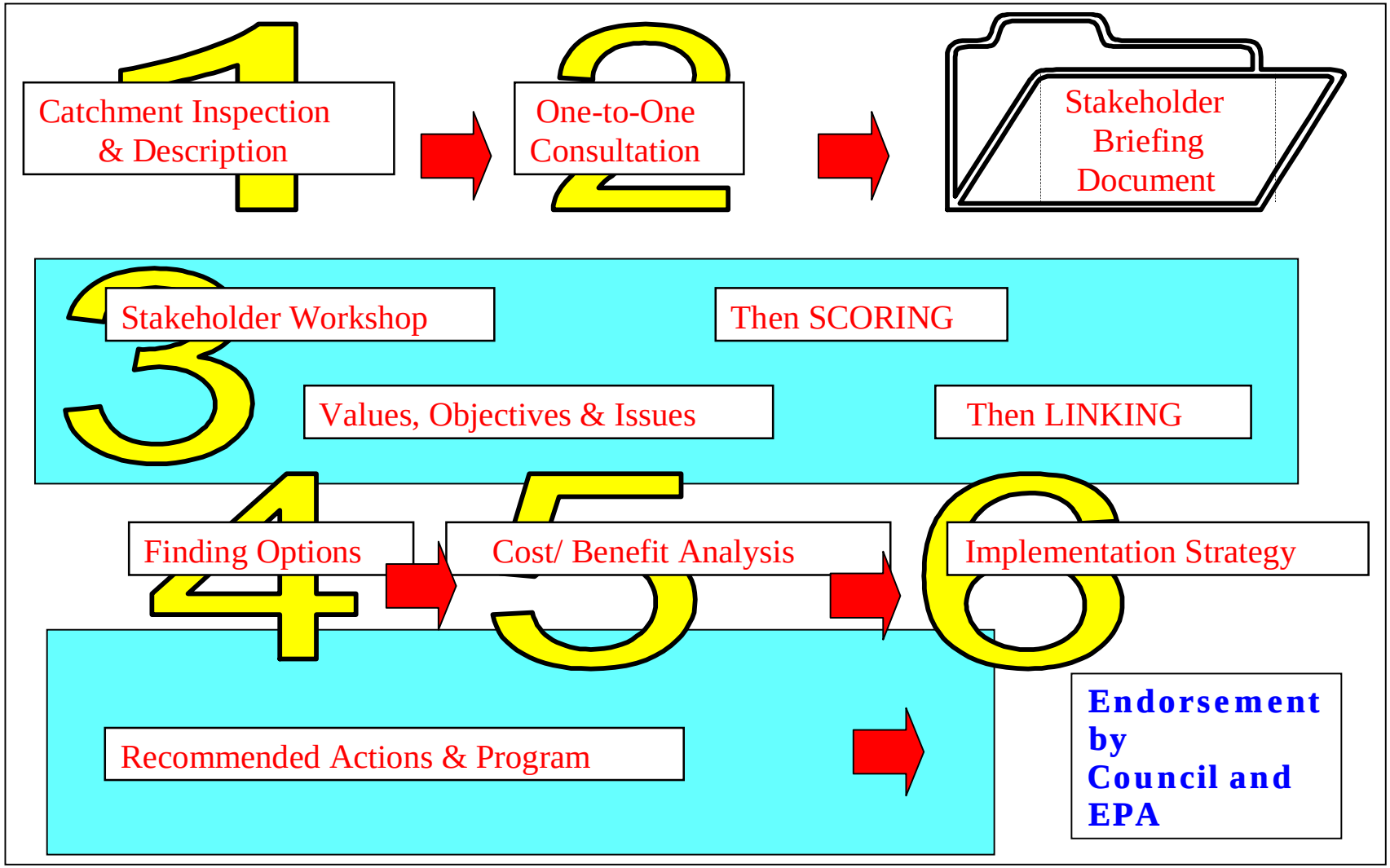
AUTHORSHIP NOTE:

This Urban Stormwater Management Plan was prepared by Hunter Water Australia – Strategic Services, at the request of Mudgee Shire Council, in accordance with a Direction issued under Section 12 of the Protection of the Environment Administration Act 1991. Preparation of this Plan has been assisted by the New South Wales Government through the Stormwater Trust. June 2001

CONTENTS

FIGURES AND TABLES

STEPS FOR THE SMP PREPARATION



GLOSSARY OF TERMS

Aquatic Habitat - This includes rivers and their channels, wetlands adjacent to the river and the riparian zone.

Matrix - Technically known as the frequency and impact study, a methodology that focuses on each issue and how it may impact on stormwater values and objectives in terms of probability and consequences.

Options - Possible solutions to stormwater management issues. From these, actions are adopted and incorporated into an implementation strategy.

Stakeholders - Individuals or groups involved in the process of preparing a Stormwater Management Plan. Stakeholders include representatives from the Council, various Government agencies, landholders and representatives from the local community. Stakeholders are involved in stormwater workshops and in the process of the preparation of the Stormwater Management Plan.

Urban Stormwater Management Plan - A plan prepared by Council to address stormwater management issues within the catchment of the urban area, particularly issues affecting water quality and quantity.

Values – Things, which we personally believe contribute to our quality of life (the anthropocentric view), or contribute to the wellbeing of the environment (the ecocentric view). In this case these involve aspects or components of the stormwater drainage system, or the environment, which interact with that system, which are valued by the community or other stakeholders.

Objectives - These are long and short term and describe how we intend to achieve our stormwater values and what we seek to achieve in our management of stormwater to protect and/or achieve the identified waterway and catchment values

Issues - Factors that may inhibit our ability to meet our stormwater objectives at present or in the future

1 – EXECUTIVE SUMMARY

The NSW Environmental Protection Authority (EPA) issued a notice under Section 12 of the Protection of the Environment Administration Act 1991 to all NSW councils early in 1998, requiring each council to develop an **Urban Stormwater Management Plan**. In response, Mudgee Shire Council commenced plan preparation in accordance with the Stormwater Management Plan (SMP) Guidelines (Managing Urban Stormwater Council Handbook, 1997) prepared by the EPA.

1.1 THE AIM OF THE STORMWATER MANAGEMENT PLAN

The Urban Stormwater Management Plan aims at addressing stormwater management problems within the catchment area, particularly water quality issues. The purpose of the Plan is to identify stormwater issues and achieve an overall improvement in the management of the stormwater system by recommending an action plan to the Council for implementing a stormwater improvement strategy.

1.2 FRAMEWORK AND SCOPE OF THE SMP

Managing stormwater is a continuous improvement process. The strategic focus is on developing, continually improving and implementing actions for encouraging the protection of stormwater environment. The Plan:

- Describes the catchment
- Identifies existing catchment conditions
- Establishes the values of the catchment
- States appropriate management objectives
- Identifies management issues and causes
- Evaluate potential management options
- Contains Plan implementation strategies
- Presents a performance monitoring program
- Describes a mechanism on the implementation of the Plan

This Plan is focused on the urban area of the catchment.

1.3 COMMUNITY CONSULTATION AND COLLECTING EXISTING DATA

Critical to the Plan is the identification of stormwater values, objectives and issues in order to develop practical stormwater management options. To assist this process, community members and Government agency representatives were consulted on a number of occasions. This included a workshop session, which was held for the study area.

This document has been prepared from the many useful comments provided to the facilitators by these stakeholders during preliminary conversations and at the workshop session. This document thus benefits from the extensive local knowledge of the stakeholders who contributed.

1.4 STORMWATER CATCHMENT VALUES

Stormwater values were developed during one-to-one-stakeholder consultations. These values were incorporated into the stakeholder briefing document.

The community considered **good water quality** to be most important and **protection of community health and safety** ranked second (see below).

Value	Score
Good water quality	285
Protection of community health/safety	205
Protection of habitats	160
Community involvement/awareness	145
Protection of properties from localised flooding	95
Recreational Value	78
Weed/exotic species control	67
Aesthetics of the catchment	65

The ranking of the values will enable the Council to establish an 'order of priority' when considering management options for the Stormwater Management Plan. This process is ongoing and values will change over time. Therefore the process of developing and implementing a Stormwater Management Plan needs to be feasible and dynamic.

1.5 THE DEVELOPMENT OF STORMWATER MANAGEMENT OBJECTIVES

Objectives can be defined as those things we seek to achieve in terms of catchment protection and stormwater management. Objectives were developed to help Council achieve their values. Considerable time was spent reviewing objectives at the workshop session. These are listed below as a summarised version including the changes made after the workshops. A detailed version can be found in section 5.0 of the report. The objectives were linked to the key values by the facilitators. This assisted to demonstrate how each objective will help to address stormwater values (Table 5.1).

Objective	Score
Improve water quality	640
Optimal infrastructure, management & design	605
Protection of community health and safety	585
Improve community awareness	560
Minimise erosion	495
Protection of aquatic and terrestrial habitats	372
Minimise localised flooding from stormwater	300
Minimise impacts of salinity	240

These were broken down into short term objectives, which provide means to achieve stormwater values in the short term and to support longer-term objectives. These may

also be called sub-objectives and play an important part in the initial stage of stormwater management in terms of working towards long term objectives. Over time, the short term objectives will be achieved and will be replaced by other objectives as the need arises.

1.6 STORMWATER MANAGEMENT ISSUES

From consultations with stakeholders and field observations, a number of stormwater issues within Mudgee and Gulgong were identified.

Stormwater issues were not ranked during the workshop however; the ranking methodology was discussed and accepted by the stakeholders. The issues were later ranked by the facilitators as listed below. For example **Insufficient community awareness** and **Decreased Water Quality** were ranked as most critical in terms of their impact on values such as water quality and aquatic habitats. A detailed list of these issues and the procedure of the ranking assessment can be found in Section 6.0.

Issue	Score
Insufficient community awareness	1,812
Decreased water quality	1,597
Infrastructure/maintenance issues	1,490
Salinity	1,440
Erosion	1,055
Planning issues	905
Localised flooding from stormwater	885
Impact on Community health & safety	585
Impact on aquatic & terrestrial habitats	372

The ranking of these issues is beneficial for the Council to establish a relative benefit when considering stormwater options.

1.7 STORMWATER MANAGEMENT OPTIONS

From the stormwater issues and objectives, a list of preferred options was developed by the facilitators, which are listed in Section 7 of this Plan. These options were further assessed in terms of efficiency in meeting the stormwater objectives and addressing key issues. This involved a cost-benefit analysis and evaluation of each option, taking into consideration the likely impact of the options on residents and the likely capital and operating costs. The Stormwater Management Plan should be flexible in terms of the implementation strategies as environmental conditions may change over time and the Plan is designed as an ongoing, dynamic document.

Also refer to section 9, which details future directions in terms of stormwater management to Council.

1.8 STORMWATER IMPLEMENTATION STRATEGIES

This component of the SMP outlines proposed expenditures over a five year period. The strategy contains an action plan, which was derived from the management options described above and includes a budget, responsibility and timeframe. The implementation strategy also provides for evaluation and monitoring of the success of

the Plan. The following table shows some of the outcomes of the cost/benefit analysis of options in the form of an action plan. Refer to Section 8.0 of this Plan for further detail.

2 - INTRODUCTION

The Mudgee Shire is located on the Western side of the Great Dividing Range. The urban areas of Mudgee and Gulgong are situated on the Cudgegong River. The shire has a population of approximately 17,000, with 7,500 residing in Mudgee and 2,250 in Gulgong.

Figure 2.1 Mudgee Shire Location Map

Source: Mudgee Gulgong Tourism Site, http://www.mudgee-gulgong.org/

The NSW Environmental Protection Authority (EPA) issued a notice under Section 12 of the Protection of the Environment Administration Act 1991 to all NSW councils early in 1998 requiring the preparation of a Urban Stormwater Management Plan for urban areas within local government areas of greater than 1,000 people. As a result of this Direction the urban areas of Mudgee and Gulgong require such a plan.

This Stormwater Management Plan aims at improving the stormwater system of Mudgee Shire and addresses specific issues such as decreased water quality, erosion, impact on habitat and lack of community awareness. Although flooding is not a key issue addressed by this Plan, it does refer to localised flooding due to stormwater issues.

This Stormwater Management Plan has been prepared in accordance with the EPA Guidelines as outlined in the NSW EPA Guidelines on Managing Urban Stormwater -

Council Handbook, November 1997. All essential elements required by the EPA for a Stormwater Management Plan are contained within this document. The Plan was prepared in consultation with the community and with the co-operation of council engineers and relevant government agencies such as the Department of Land and Water Conservation, National Parks and Wildlife, Department of Public Works and Services, Roads and Traffic Authority, and NSW Agriculture. Through this process it was found that no government agency had any stormwater responsibilities in the area.

The implementation strategy will also outline activities and expenditure for both long term and short term management and ensures that expenditures are compatible with the Council's proposed expenditures. In addition, the Plan will identify additional projects and potential funding for activities to be undertaken by external sources such as Landcare/Rivercare, the Department of Land and Water Conservation and other relevant environmental groups. The Plan also aims at a higher level of community involvement and education.

This Plan is not designed to be read in isolation. To ensure maximum stormwater management results, this Plan should be integrated with relevant existing and future management plans. The integration with other plans will ensure uniformity and minimise duplication.

2.1 PURPOSE OF THIS PLAN

The aim of the Urban Stormwater Management Plan is to achieve an overall improvement of the stormwater system and its associated environment, including:

- Increasing **community awareness**, education and interest of the importance of the stormwater catchment and the importance of a Stormwater Management Plan
- Improving **stormwater quality**
- Minimising the impact on aquatic and terrestrial **habitats** associated with the Mudgee urban stormwater system;
- Reducing impacts of **erosion** on natural habitat and its impact on water quality
- Improving the overall **aesthetics** of the stormwater system;
- Minimising the impact of **health and safety** issues of the community in association with stormwater system;
- Addressing relevant **planning and flooding** issues within the urban catchment;
- Ensuring that stormwater management is at reasonable **cost and maintenance**

Council, in cooperation with local community and relevant Government agency representatives have developed the Stormwater Management Plan. The following components will be included in the Plan:

- A description of the existing stormwater catchment (Section 3)
- The identification and ranking of stormwater values (Section 4)
- The development of stormwater objectives (Section 5)
- The identification and ranking of stormwater issues (Section 6)
- Potential management options for the stormwater, including a cost-benefit analysis (Section 7)
- Implementation strategies (Section 8)
- Monitoring and reporting (Section 9)

2.2 FRAMEWORK FOR PREPARING THIS PLAN

This Plan has been prepared in accordance with the notice issued to the Council by the EPA in Section 12 of the Protection of the Environment Administration Act, 1991.
Managing stormwater is a continuous improvement process. This document is Council's first such plan and is regarded as a management tool, and the strategic focus is on developing, continually improving and implementing actions for encouraging the protection of stormwater environment. The Plan:

- Describes the catchment
- Identifies existing catchment conditions
- Establishes the values of the catchment
- States appropriate management objectives
- Identifies management issues and causes
- Evaluate potential management options
- Contains Plan implementation strategies
- Presents a performance monitoring program
- Describes a mechanism on the implementation of the Plan

2.3 SCOPE OF THIS PLAN

This Plan is focused on the urban area of the catchment. The urban area can be defined by the demographics (the greatest concentration of residents) and the Council's zoning. This may include both ephemeral and constantly flowing creeks.

2.4 STAKEHOLDER CONSULTATION

External facilitators were engaged by Council to facilitate the workshop sessions, community consultation process and the preparation of the Urban Stormwater Management Plan on behalf of Mudgee Shire Council. The community consultation process involved one-to-one meetings with 14 stakeholders, phone conversations and a workshop session attended by 9 stakeholders and community members. Details of stakeholder involvement can be found in Appendix C. The workshop session was facilitated by Hunter Water Australia Strategic Services and was attended by representatives of the following:

- Department of Land and Water Conservation
- Mudgee Environment Group
- Council
- Interested Community members

During the workshop, participants provided input and feedback on various components of the Stormwater Management Plan. The community consultation process also involved phone conversations with individual stakeholders to outline the process and to clarify any points of confusion.

2.5 BACKGROUND

Runoff from urban areas is referred to as urban stormwater, including major flows during and after rain, and dry weather flows. Various factors influence the amount of stormwater and its contaminants, including:

- Duration and intensity of flow;
- Topography;
- Type of land use and the proportion of impervious surfaces;
- The design and management of the stormwater system.

Other material in stormwater that is collected by rainfall includes litter, dust and soil, chemicals and pesticides, fertilisers and other nutrients, micro-organisms and grease and oils. The majority of the rainfall in rural areas infiltrates into the soil, some evaporates and the remaining stormwater runs into the streams. In highly urbanised areas, especially industrial areas with large sealed grounds, the majority (up to 90%) of the stormwater makes its way into the drainage system. Wet weather overflows from sewage systems may be part of the stormwater flows in some areas. Other features of the urban drainage include dry weather drainage flows from garden watering, washdown and discharges.

Stormwater can have varying degrees of impact on environmental values and the value of receiving water bodies. The Stormwater Management Plan attempts to facilitate community participation, incorporate catchment wide implications in decision making, take into consideration the community's values and interests, and manage the catchment in a cost-effective manner. The Plan is responsive to social, environmental and economic concerns in a balanced manner.

2.6 INTEGRATION OF THIS PLAN WITH OTHER STATE GOVERNMENT INITIATIVES

2.6.1 Total Catchment Management (TCM)

The legislative basis for TCM is provided by the new Catchment Management Regulation 1999 which came into force on the 1st March 2000. This regulation establishes Catchment Management Boards and Trusts under the Catchment Management Act 1989. The Murray Darling Catchment Management Board is relevant to this plan.

TCM provides a cooperative approach to addressing some of the natural resource problems that exist in catchments. TCM provides a mechanism for involving everyone within the catchment in considering the impacts of their activities on others and on the catchment itself. TCM links community and Government and the community 'owns' the recommendations arising through TCM.

The Catchment Management Boards operate on a catchment wide basis and identify key land, water and vegetation problems. The first task for each of the catchment management boards will be to develop Catchment Management Plans.

Landcare was not incorporated into the Catchment Management Act due to the recognition of their autonomy and independence as the main factors in their success. Yet, the ethos and concepts of TCM are consistent with and complement the principles of Landcare. The interactive and independent relationship of Landcare and TCM is unique in NSW.

2.6.2 Department of Land and Water Conservation (DLWC)

In recent years the New South Wales Government introduced a water reform package, addressing water quality and river flow objectives, the need for catchment planning and pricing reforms. The DLWC is responsible for developing catchment planning programs, sewage reuse projects and better land use planning for new developments. The DLWC developed Landcare/Rivercare planning material to assist the identification of actions, which must be implemented to improve river systems and landuse practices. An additional initiative is the Healthy Rivers Commission (HRC). The HRC aims at improving catchment health by bringing together government and community in order to combine resources and address water quality problems.

The challenge lies in educating the whole community about the role each and everyone has in repairing the damage that has been done to our environment. Improving community awareness in terms of environmental issues is the first step towards improving the health of the environment.

The DLWC in conjunction with other agencies and groups has raised community awareness through a number of programs about water quality problems and poor land and water management practices. Stormwater Management is one of these programs managed primarily by the EPA.

2.6.3 Landcare Groups

Landcare groups provide the community with opportunities to work together, address important Landcare problems and develop their skills. The aim is to help the community to become aware of land and water degradation issues in the local area.

The Catchment Management Committees and Trusts (CMC/T) have the responsibility for coordinating natural resource management within their catchment and provide Landcare groups with information on regional priorities and may have useful ideas on projects.

Typically Landcare Groups carry out some of the following activities:

- Tree planting to minimise erosion;
- Weed removal;
- Rehabilitation and restoration of riparian vegetation and bushland areas;
- Water quality monitoring (on a limited basis);
- Restoration and creation of wetlands
- Assessment of flora and fauna in catchments;
- Environmental education.

TCM works at a strategic level, whereas Landcare carries out much of the “on-ground” work.

2.6.4 Rivercare 2000

Rivercare is a community program that works with DLWC on a catchment or sub-catchment basis. It is a NSW Government initiative and its main objective is to increase community awareness of the riverine environment, and to help community

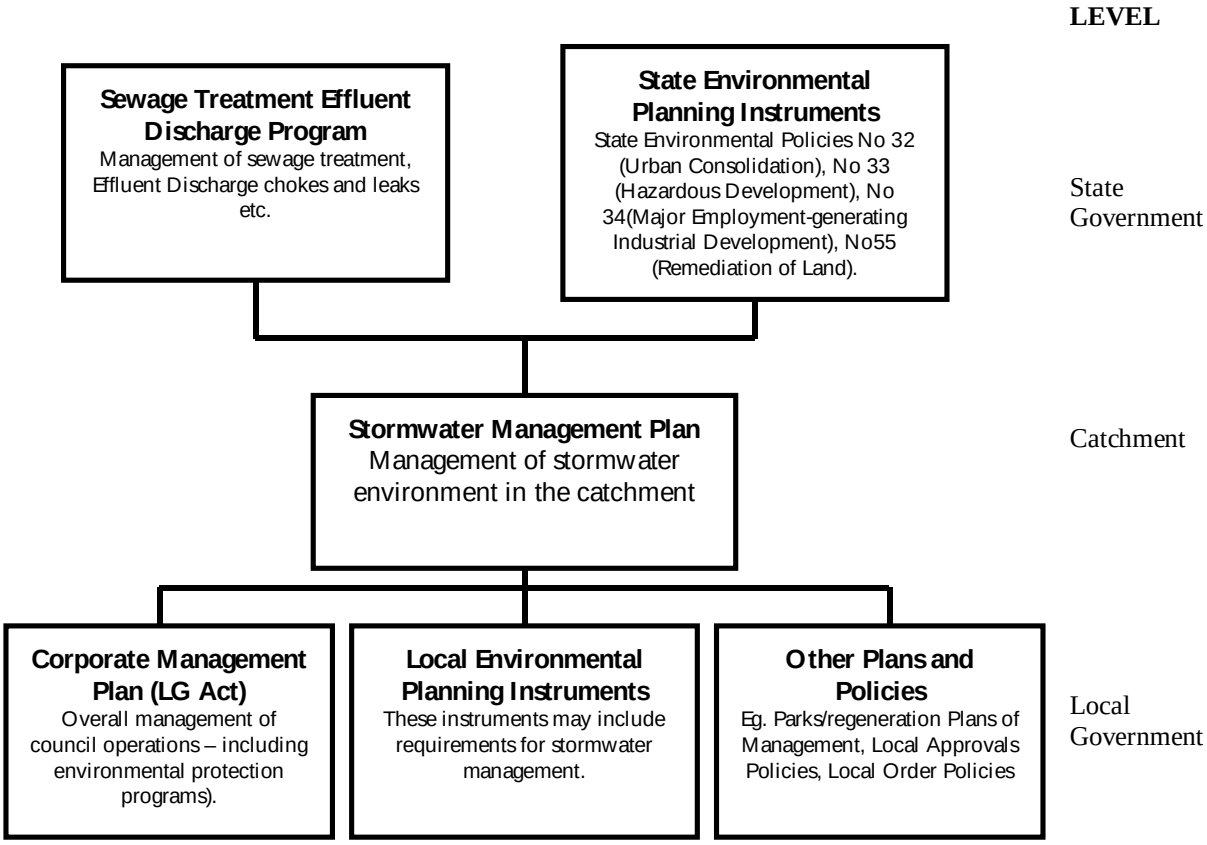
groups and other organisations to become actively involved in local stream and river management. The main aim of Rivercare is the on-ground restoration and rehabilitation of rivers and streams. River and stream environment information is captured in photographs at community workshops during which recommendations are discussed on native vegetation, management of rural stock, water quality monitoring, etc. Rivercare also considers septic effluent, geomorphic situations in creeks and rivers, fishery regulations, and is involved in urban situations in terms of water quality.

2.6.5 How does the Stormwater Management Plan link to TCM, Landcare and Rivercare?

The Stormwater Management Plan is not designed to stand alone. A crucial aspect of stormwater management is to work in close association and coordination with the above groups to achieve best practice management for the catchment area.

The Stormwater Management Plan only focuses on a small part of the catchment, the urban catchment. TCM covers the entire catchment and includes rivers, creeks, vegetation and landuse issues. Landcare and Rivercare are more site specific than TCM. Hence the SMP could be used in other documents for site specific studies and other management plans may expand on what has been established in the SMP.

2.6.6 Relationship of Stormwater Management Plan with other Plans and Policies



2.6.7 Relevant Local Studies Relating to Stormwater Management in Mudgee and Gulgong

In 1998, Lyall and Macoun Consulting Engineers carried out a series of Hydrology Studies of the stormwater catchments of Mudgee and Gulgong. These studies highlighted a number of hydraulic deficiencies in the towns' stormwater systems, including a general lack of basic drainage infrastructure. The findings and some of the recommendations from these reports have been included in section 3.7 – Hydrology.

Additionally, Mudgee Shire Council is currently developing a Floodplain Management Study and Plan for the Cudgegong River and Redbank Creek within Mudgee.

The outcomes of the Floodplain Management Plan and the recommendations by Lyall & Macoun (1998) should be integrated with the Stormwater Management Plan to ensure consistency across all related studies.

3 – CATCHMENT DESCRIPTION

The NSW EPA requires a description of the characteristics of the urban catchment and its waterways for the preparation of the Stormwater Management Plan. The purpose of the collection of the existing catchment data is to determine stormwater values, prioritise areas of investigation and to identify constraints and opportunities for improving stormwater management.

The catchment description includes physical characteristics, social characteristics, waterways characteristics and ecological characteristics. The catchment description was prepared using previous studies and through catchment inspections with the aid of a Catchment Audit Protocol, the results of which appear in Appendix B. For a map of the subcatchments in Mudgee and Gulgong, please refer to Appendix J.

3.1 OVERVIEW

The Mudgee Shire covers some 3840 square kilometres and is located on the Western side of the Great Dividing Range. The shire lies between 470 and 1,000m elevation. The central business area for the shire is the town of Mudgee, which is located 261km northwest of Sydney, on the Cudgegong River. The shire has a population of approximately 17,000, with 7,500 residing in Mudgee and 2,250 in Gulgong. The area is a prominent wine producing region and is a major producer of wool.

3.2 WATERWAYS

This section aims at identifying the major waterways within the urban catchment and provides a general description of the shire of Mudgee.

MUDGEE

Stormwater run-off from Mudgee drains to the Cudgegong River. The Cudgegong River is a tributary of the Macquarie River and is significant in the region. Windamere Dam is located on the river and regulates the river flow which experiences low variability. Previous stormwater drainage studies (Lyall & Macoun Consulting Engineers, 1998) divided the town into 7 sub-catchments (Catchments A-G).

Catchment A rises in the hilly country to the south of the town, flowing through a small urbanised area before discharging to the Cudgegong River. The downstream areas of Catchment A are quite flat and the watercourse becomes less defined. The main watercourse crosses Saleyards Lane and discharges into a large paddock where flows disperse and are conveyed as overland flow to the River. Stormwater is conveyed in natural channels

Fig1.1 The creek downstream of Saleyards Lane

Catchment B rises on the northern side of Flirtation Hill, and drains Cox Street before discharging into a small watercourse and to the River. Stormwater infrastructure in this catchment includes open gutters.

Fig1.2 The discharge point from Catchment B, joining the watercourse from Catchment C

Catchment C rises in the hilly country south of Mudgee and drains the urbanised areas around Douro and Court St. Much of the natural creek system in the upper reaches of the catchment have been piped in order to cope with increased flow from recent development in the area. A large detention basin was constructed in the Mudgee Showground in the 1980s, attenuating flow from the urbanised upper reaches. A concrete dish drain is in place in a large portion of the creek downstream of the basin. Downstream of Short St, low flow is directed through a small constructed wetland, with a grassed swale directing higher flows into the same waterway as flows from Catchment B, prior to entering the river.

Fig1.3 Small constructed wetland in the downstream area of Catchment C.

Fig1.4 The grass swale adjacent to the constructed wetland

Catchment D includes much of Mudgee's Central Business District and has a high percentage of impervious area. Flows in the upstream areas of the catchment are conveyed mainly by open roadside drains. As flows pass through the commercial area of Church St, there is currently no kerb and gutter system in place, but a series of inlet pits into an underground piped system which struggles to cope with high flows and results in flooding in the CBD. Council currently has plans to upgrade the drainage of the CBD, with the installation of a new trunk drainage line under Church St. Currently, and as part of the new works, flows are discharged directly to the Cudgegong River over a gabion mattress in Lawson Park.

In the upper reaches of **Catchment E** flows are conveyed within the road gutter system, along Lewis St and into Gladstone St. Upstream of Mortimer St, the channel has been formalised into a 3m wide concrete v-drain, with a vertical sided concrete channel directing flows to the river.

The upper areas of **Catchment F**, upstream of the railway line, are mainly piped. The piped network drains into an open channel immediately upstream of the railway line. Downstream, an open channel conveys flows to the Cudgegong River.

Catchment G is essentially the catchment of Redbank Creek. With flows controlled by the Redbank Dam, formerly used as a water supply source, Redbank Creek skirts the south-eastern parts of Mudgee before draining through the Golf Course and the Industrial Area along Sydney Rd. Downstream of the industrial area, Redbank joins Oaky Creek before flowing into the Cudgegong River.

GULGONG

The drainage study by Lyall and Macoun (1998) identified two catchments (X and Y) in the town of Gulgong. The two catchments are divided by a ridge extending northwards from the intersection of Fisher and Herbert Streets to Rouse and Wynella Streets. In each of these catchments stormwater is conveyed as overland flow along the street system. In limited areas a piped drainage system exists of minor pipe sizes.

Catchment X drains the western side of the ridge, with runoff continuing in a westerly direction across rural land. The southern portion of the catchment is the most urbanised, with small residential allotments.

Catchment Y drains the eastern side of the ridge, in a northerly direction towards rural land. Catchment Y is the most urbanised of the two. In the upper residential reaches stormwater flows via the roadside depressions.

Specific streamflow data for the Cudgegong River, Redbank Creek and the urban stormwater system is not currently available.

3.3 LAND USE

The following section is important in the development of the Stormwater Management Plan in that it gives an overview of the area used for urban development, farming and other industries. Landuse is considered to help interpret and understand the causes of land degradation. The land use may be a potential source of pollution, which may impact on water quality.

Mudgee is a prominent farming and grazing area and there are issues associated with these types of land use that have the potential to increase the level of stormwater and runoff and decrease its quality. However, farming and grazing within the study area (ie. the urban area) is minimal.

Within the study area the land use is mostly residential with some commercial and industrial areas. The main commercial centre is along Market and Church Streets. The industrial area is essentially “commercial-industrial” and contains outlets such as motor vehicle yards, fabrication companies, heavy machinery sales and produce supplies.

Gulgong is also mainly residential and commercial, with a small industrial area in the north-eastern part of town. Industries in Gulgong include a fuel depot, flour mill and steel fabrication.

A map of Council’s landuse zoning areas will be included as part of the final Stormwater Management Plan.

3.4 TOPOGRAPHY

The topography of the area of interest is important in terms of its direct association with water runoff, which in turn relates to erosion of the soil.

The terrain in the urban area of Mudgee is relatively flat, with slight hills rising in the south of the town. Immediately south of the town, steep hillsides are present, particularly in the Avisford Nature Reserve, which constitutes the upper reaches of Catchments A and C. These hillsides are well vegetated, so erosion and subsequent sedimentation downstream is not a major concern.

Gulgong slopes steadily from its highest point on Flirtation Hill (500m AHD) to around 450m AHD in the rural lands to the north of the town. The town is separated

by a ridge, separating the town into two main catchments. The ridge runs from the Fisher and Herbert St intersection in the south of the town to the intersection of Rouse and Wynella St at the northern end of the urban area.

3.5 GEOLOGY AND SOIL

The geology and soils of the catchment need careful consideration in the development of the Stormwater Management Plan. Erosion and soil drainage are directly affected by the nature of soil. For example, stony basalt soil has a poor soil drainage capacity and gravelly soils cause high erosion hazards. Generally, sandstone forms a shallow, low fertile soil with low water-holding capacity and limited biological productivity. The finer grained siltstones, mudstones and shales tend to weather more rapidly and form moderately productive soils with good moisture and nutrient holding characteristics if managed properly. The following information is from Murphy and Lawrie, 1998.

The Cudgegong alluvial soils are found along the alluvial plains and terraces of the river. Characteristics of these soils include moderate fertility and waterholding capacity with weakly structured surface soils. As a result, streambank erosion affects some areas.

The main parts of the towns of Mudgee and Gulgong are characterised by the Craigmore Non-Calcic Brown Soil Landscape. These soils have a moderate to high fertility, weakly structured surface soils and a moderate to high waterholding capacity. Under cultivation, the Craigmore Soils have a moderate to high erosion hazard.

3.6 CLIMATE

Climate is an important factor for appropriate stormwater management. Stormwater effluent in wet weather conditions may differ considerably to effluent in dry weather conditions.

Mudgee Shire Council (2000) describes the climate as temperate with cool winters to hot summers. The temperature ranges from mild winters with an average daily maximum temperature of 14.4^{o}C in the coldest month July, to very warm to hot Summers with mean daily maximum temperatures of 31^{o}C in the warmest month January. The humidity averages through the year in Mudgee at 78.8% and 76% in Gulgong.

The average annual rainfall recorded at Mudgee is about 675 millimetres and 650 millimetres at Gulgong. Rainfall tends to be marginally summer dominant with average monthly rainfall ranging from 45.2mm in April to 69.1mm in January. Similarly rainfall in Gulgong is more dominant in the summer months ranging in average monthly rainfall from 45.6mm in April to 72.3mm in January.

Table 1.1 and Table 1.2 represent the average annual rainfall data. Evaporation data is not available.

Table 1.1– Average Rainfall for Mudgee, NSW.

Month	Average Rainfall (mm)
JANUARY	69.1
FEBRUARY	61.6
MARCH	51.1
APRIL	45.2
MAY	50.8
JUNE	54.8
JULY	53.7
AUGUST	53.8
SEPTEMBER	52.2
OCTOBER	60.6
NOVEMBER	59.4
DECEMBER	63.5
TOTAL	**675.7**

Source: Bureau of Meteorology, http://www.bom.gov.au

Table 1.2- Average Rainfall for Gulgong,.NSW.

Month	Average Rainfall (mm)
JANUARY	72.3
FEBRUARY	59.0
MARCH	54.5
APRIL	45.6
MAY	46.6
JUNE	50.4
JULY	48.9
AUGUST	47.0
SEPTEMBER	46.9
OCTOBER	56.9
NOVEMBER	58.2
DECEMBER	64.3
TOTAL	**650.6**

Source: Bureau of Meteorology, http://www.bom.gov.au

3.7 HYDROLOGY

Terrain and hydrology of the catchment are important factors to be considered in stormwater management. The hydrology within the towns of Mudgee and Gulgong was investigated and documented in the Stormwater Drainage Studies (Lyall & Macoun Consulting Engineers, 1998).

As described in Section 1.1, the Studies divided the town into a number of catchments.

The Drainage Studies identified several problem areas that were prone to flooding:

- Mortimer St, Mudgee

- Nicholson St, Mudgee
- Between Lawson St and the Cudgegong River, Mudgee
- Intersection of Moonlight and Wenonah Streets, Gulgong
- Anderson St and Menchin Lane, Gulgong

Additional problem areas and possible solutions identified in the Lyall & Macoun Reports include:

Mudgee Catchment A: Replace causeway on Bellevue Rd with a culvert; Culverts under Rifle Range Road, Fairydale Lane and Saleyards Lane all have < 5 year ARI capacity. From Rifle Range Rd to 300m downstream, approximately 12 drop structures are required to reduce flow velocities to non-scouring values.

Mudgee Catchment B: Trunk drainage works required to prevent minor flooding near Short Street.

Mudgee Catchment C: Road crossings of major trunk drainage line are inadequate in the 5 year ARI design storm event at Madeira Rd, Nicholson St footbridge, Nicholson St, Inglis St, Perry St, and Short St. Culverts are inadequate for the 100 year ARI design storm at Douro St, Gladstone St, Mortimer St, Market St, and Court St. Localised flooding results.
Additional areas requiring attention include drainage upstream of Madeira Rd, in the vicinity of Cudgegong Valley Public School, and improvements to the channel downstream of Mortimer Street to prevent surcharging floodwaters over the right bank extending into adjacent properties.
A gross pollutant trap is required before storm water enters the Cudgegong River.

Mudgee Catchment D: Drainage works are required at Mortimer Street and Market Street to prevent localised flooding in these commercial areas. A gross pollutant trap is required at the outlet of the new stormwater main within Church Street.

Mudgee Catchment E: The open channel between Lawson Street and the Cudgegong River has a capacity less than the 5 year ARI design flow. Regular flooding of properties occurs south of Mortimer Street, where additional culverts are required.

Mudgee Catchment F: Stormwater system has a capacity less than 5 years ARI. Improve storm water infrastructure by providing grated inlet pits and lintels, increasing the number of inlet pits, and increasing the waterway area of the piped network. Detention storage may potentially be beneficial within Cahill Park, or by formalising the dam within the golf course as a retardation structure.
Improvements to culvert capacity are required at Inglis Street, Denison Street, property access track 80m upstream of George Street, and at George Street.

Mudgee Catchment G: Culvert upgrading works are required where Redbank Creek crosses Waterworks Road. Flooding can be minimised by managing Redbank Dam to maintain a flood storage component. Creek amplification works will also be required in the vicinity of Waterworks Road, depending on the management strategy adopted for the dam.

Gulgong Catchment X: Insufficient inlet capacity at the intersection of Medley & Herbert Streets leads to surcharging of inlet pits and road crossings in relatively minor storm events. The same problem is also evident at the crossing of Fisher and Wilbetree Streets.
Overflows from Bligh Street surcharge onto the golf course in minor storm events. The pipe system requires augmentation at Mayne Street (to and under Fisher Street), Robinson Street (from Fitzroy to Fisher Street), and Wilga Road (Fisher St to downstream of Bunderra St).

Gulgong Catchment Y: Crossing of Moonlight St & Wenonah St requires kerb & gutter to prevent flows from entering private properties.
Inlet capacities in the vicinity of Anderson Street and Menchin Lane require augmenting to capture all overland flow, and kerb and gutter constructed to prevent storm water runoff from entering allotments.
A major piped drainage system is necessary to protect houses from localised flooding in Moonlight Street (55m of 525ϕ from Menchin Lane to Bowman St), Bowman St (140m of 525ϕ from Moonlight St to Belmore St), Rouse St (220m of 450ϕ from Cainbil St to Herbert St), Medley St (180m of 600ϕ from Worobil St to Rouse St), Herbert St (360m of 450ϕ from Lynne St to Rouse St), White St (100m of 525ϕ from Bayly St to Little Bayly St), Nandoura St (660m of 750ϕ from Lowe St to Station St), Station St (140m of 600ϕ from White St to Nandoura St), and Rouse St (30m of 1050ϕ from Station St to open channel).

3.8 FLUVIAL GEOMORPHOLOGY

Fluvial geomorphology studies aim at identifying areas prone to erosion and sedimentation patterns. The reasonably flat nature of the town means that erosion is minimal and confined to streambanks near stormwater outlets in times of peak flow events (such as the main outlet in Lawson Park). The bank around this outlet has been protected by a gabion, however erosion is occurring around the edges of the material (Fig 1.5).

Fig1.5 River bank erosion adjacent to the gabion at the outlet in Lawson ark.

3.9 WATER QUALITY

Water quality data needs to be considered in the Stormwater Management Plan to determine receiving water quality and potential major pollution sources. Poor water

quality may be due to erosion, extensive gully grazing, development activities, geological formations that are high in phosphates or salts and landuse activities. Table 1.2 summarises the characteristics of stormwater and outlines the guidelines associated with acceptable water quality standards.

Runoff Quality

Many of the substances present in water that may be classified as 'pollutants' (at excessive concentrations) are essential to the function of aquatic ecosystems. These include:

- *Suspended solids* – contain organic matter for processing by microorganisms and aquatic invertebrates; and,
- *Nutrients* – encourage the growth of aquatic plants and algae. In freshwater systems, this 'primary' biological productivity is generally controlled by the amount of phosphorous present, while nitrogen often limits productivity in estuaries.

Table 1.2 Water Quality Parameters and Guidelines

TEST	IMPORTANCE TO STORMWATER	ANZECC, 1992 GUIDELINES
Temperature	Temperature influences the amount of oxygen that can be dissolved in the water and the diversity of aquatic organisms that can survive.	Increases in temperature should be less than 2°C.
Turbidity	Turbidity is the measure of the clarity of the water and is caused by suspended solid matter in the form of sediment, plankton, algae, sewage and/or industrial waste.	< 5NTU
Total Dissolved Solids (TDS)	The TDS test is a measure of the dissolved salts in the water.	100 to 1000mg/L for freshwater rivers
pH	pH is a measure of the acidity or alkalinity of a substance. Changes in pH outside the normal range will cause a reduction in species diversity	6.5 to 9.0 (freshwater aquatic ecosystems) 5.0 to 9.0 (recreational waters) 4.5 to 9.0 (agricultural water uses)
Dissolved oxygen (DO)	DO is important because all fish, invertebrates and amphibians need oxygen to breath and stay alive.	DO should not fall below 80-90%. Levels of at least 5-6mg/L are required for fish growth and activity.
Biochemical Oxygen Demand (BOD)	BOD is a measure of the amount of oxygen that has been consumed by biological processes over a 5-day period.	Unpolluted waters = 5mg/l or less Raw sewage levels may be 150 to 300mg/L Treated sewage levels may be 20 to 30mg/L Polluted stormwater may have readings of 200 to 600mg/L
Phosphorus	Phosphorus is an essential plant and animal nutrient that occurs naturally in low concentrations in Australian soils and water. It limits and controls the rate and the abundance of plant growth. High levels increase algae and weed	For rivers and streams the Total Phosphorus (P) is 0.010 – 0.100 mg/L and the Total Phosphorus (PO_4) is 0.030 – 0.300mg/L

	growth and blue-green algae blooms.	

Very little water quality monitoring data for the Cudgegong River is available. According to the 2000 State of the Environment Report, macroinvertebrate assemblages are monitored at two locations within the Mudgee Shire, with river and stream health generally regarded as fair.

Sewer overflows have occurred throughout the stormwater catchment however a major point source is at Lawson Park in Mudgee. These sewer overflows flow into the Cudgegong River.

3.10 RIPARIAN, FORESHORE VEGETATION AND BUSHLAND

Riparian vegetation is referred to as vegetation on or near creek or river banks. Riparian vegetation is important in terms of erosion control and to maintain good water quality of the waterways. The upper catchment contains areas of significant riparian vegetation.

The removal of willows and the reinstatement of riparian vegetation has been a priority of both the community and Mudgee Shire Council. Willow removal and the subsequent replanting of Riparian areas with endemic or native species will assist in riverbank stabilisation, improving water quality and assist in reducing the dominance of other weed species in the riparian zone.

Significant effort has been devoted to the removal of pest plant species in riparian areas over the last year. Council and the community have contributed to the removal of 10km of willows. This work was the largest stretch of willow removal undertaken in the Central West and Orana Region.

Natural bushland areas within a catchment are important as habitat for native species and to maintain wildlife corridors throughout the catchment. The biodiversity of the catchment is also increased as a result of natural bushland areas. Within the urban catchment of Mudgee there are areas of native bushland in the upper catchment. Some of these areas have been protected in a nature reserve or park.

3.11 AQUATIC ECOSYSTEMS AND HABITAT

Little information is available on the extent of aquatic ecosystems in the Mudgee and Gulgong areas. Anecdotal evidence and advice from stakeholders suggests that the Cudgegong River through Lawson Park in Mudgee is a known Platypus habitat.

3.12 POINT SOURCES OF POLLUTION

It is the nature of urban stormwater systems that most stormwater pollution comes from “non-point” or “diffuse” sources. Some point sources of pollution in the area include the Mudgee and Gulgong industrial areas

4 – STORMWATER VALUES

The facilitators contacted each stakeholder prior to the stakeholder workshop to explain the process involved in developing the first phase of the Stormwater Management Plan, to clarify definitions and to seek information on stormwater values and issues within the catchment area. This allowed for the preparation of a preliminary list of values that stakeholders thought to be of importance for stormwater management. During the workshop session the values were reviewed to produce Table 4.1. The EPA suggested that values be placed into the categories of social, economic and ecological values.

Values can be defined as:

Things which we personally believe contribute to our quality of life (the anthropocentric view), or contribute to the wellbeing of the environment (the ecocentric view) and in this case involve aspects or components of the stormwater drainage system, or the environment which interacts with the system, which are valued by the community or the stakeholders.

During the consultation process the aim was to discover personal values and to compare them with those of other stakeholders. This process is ongoing and values will change over time. Therefore the process of developing and implementing a Stormwater Management Plan needs to be flexible and dynamic. The ranking of values was accomplished during the workshop session with the aid of a methodology of individual assessment and consensus gathering as explained below. Some stakeholders may find it easier to see values in terms of 'visions' or 'likes'. These values are not presented in any particular order and no limit was set on the amount of stormwater values.

For more detail on the methods used throughout the plan to identify and rank values, objectives, and issues, see Appendix H.

VALUES RAISED BY STAKEHOLDERS

Social Values

- Good water quality
- Community health/safety
- Community involvement/awareness
- Recreational Value (Primary Contact)
- Aesthetics of the catchment

Environmental Values

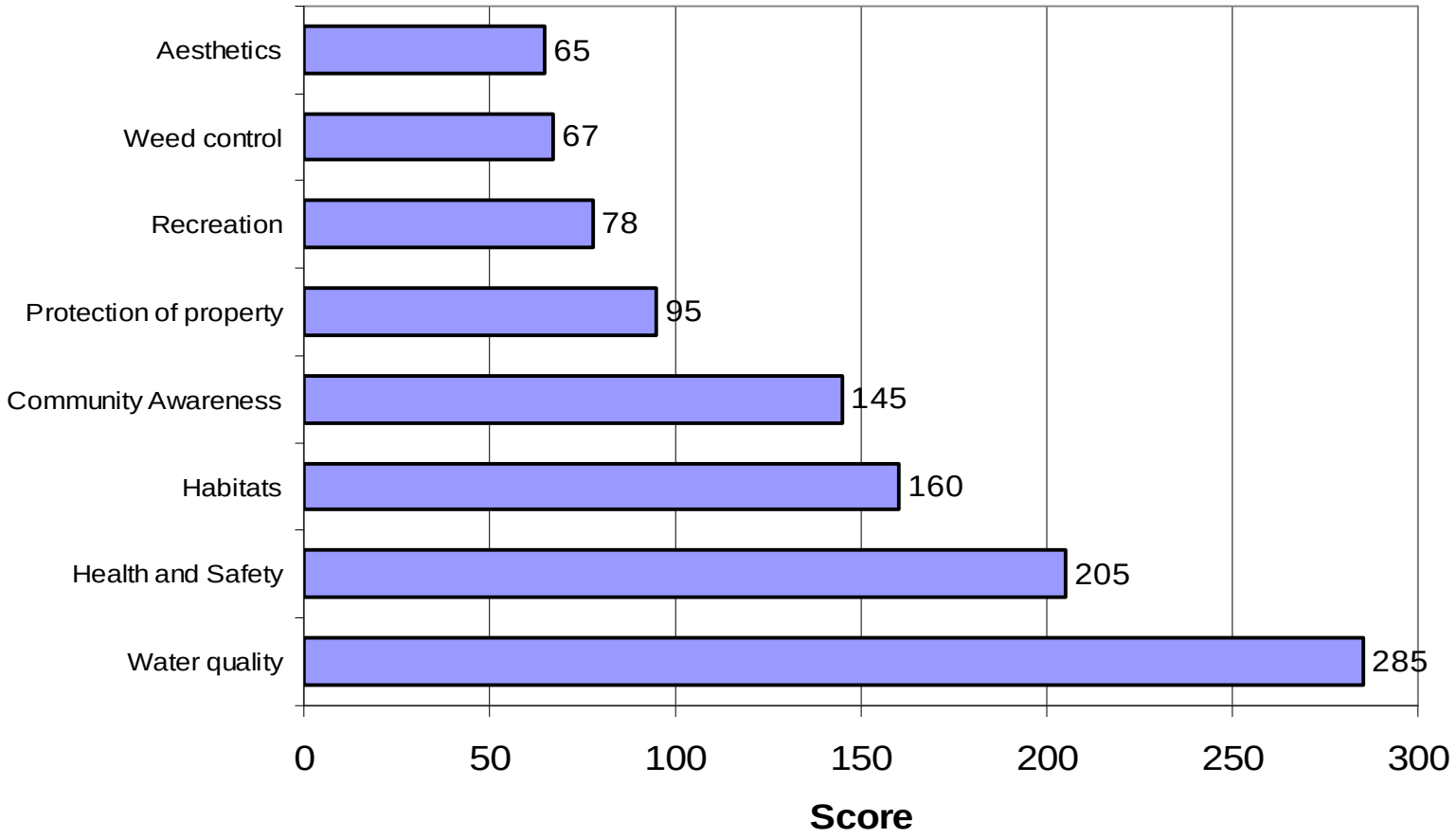
- Good water quality
- Protection of habitats
- Weed/exotic species control

Economic Values

- Protection of properties from localised flooding

The community ranked good water quality and protection of health and safety as the most critical issues to be addressed. The scoring can be seen in the following bar graph:

FIGURE 4.1: VALUES RANKING



5 – STORMWATER MANAGEMENT OBJECTIVES

Objectives can be defined as:

Objectives are long and short term and describe what we seek to achieve in terms of catchment protection and the stormwater values. They also state what we seek to achieve in our management of stormwater to protect and/or achieve the identified waterway and catchment values.

The important thing to remember with assembling a list of objectives is to recognise that often a single objective will deliver to the community positive results on more than one of the identified values (see Table 5.2 for linkages between objectives and values). This means that as we assemble a list of objectives we will find that some of them will be capable of delivering more than others and in fact some of the objectives will be long term and some short term. Short term objectives should aim towards gaining a better understanding of the catchment from which long term objectives can evolve and establish strategies to reach the long-term objectives.

Stormwater management should aim to work within the framework of Ecological Sustainable Development (ESD), ie 'development that improves the total quality of life, both now and in the future, in a way that maintains the ecological process on which life depends'.

Ecologically sustainable development requires the effective integration of economic and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following principles and programs:

(a) the precautionary principle namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:

  (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and

  (ii) an assessment of the risk-weighted consequences of various options,

In the stormwater planning process, the Precautionary Principle should be exercised in future planning and development, particularly with reference to capital works and new developments.

(b) inter-generational equity namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations, . In stormwater management this relates to ensuring that there while there is enough capital available now to undertake works, we should also undertake environmental works such as rehabilitation and revegetation to conserve the natural environment for future use.

(c) conservation of biological diversity and ecological integrity namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration, in stormwater management, especially incorporated into monitoring and review frameworks to ensure that management is protecting these features.

(d) improved valuation, pricing and incentive mechanisms namely, that environmental factors should be included in the valuation of assets and services, such as:

  (i) polluter pays that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,

  (ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste

  (iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

(e) The full environmental cost of stormwater management objectives should be accounted for in economic costs. This includes consideration of source point and diffuse pollution.

A detailed explanation on the identification and ranking of values, objectives and issues can be found in Appendix I.

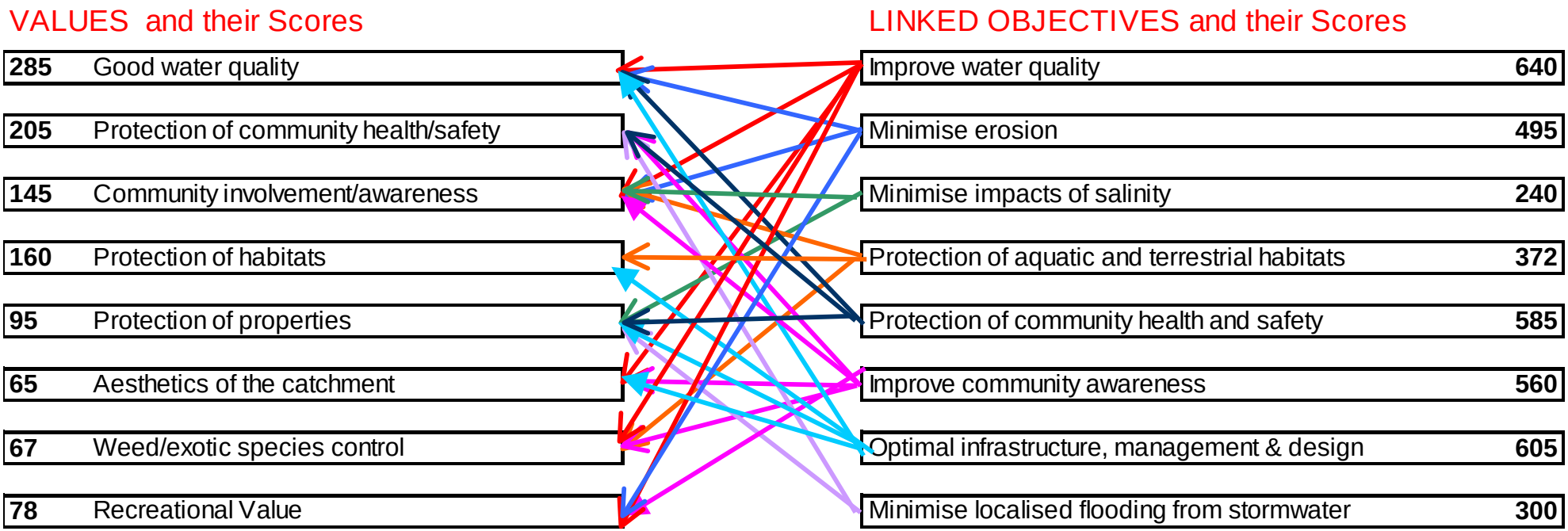
TABLE 5.1 STORMWATER MANAGEMENT OBJECTIVES

LONG TERM (Overriding Objectives)	SHORT TERM (Sub-objectives)
IMPROVE WATER QUALITY	
Improve and maintain water quality within ANZECC (1992) Australian Water Quality Guidelines for Fresh and Marine Waters.	• The amount of litter entering waterways, especially from the CBD reduced • The risk of contaminated run-off entering waterways from the industrial area reduced. • The amount of bacterial contamination due to sewer surcharges reduced.
MINIMISE EROSION	
Minimise the impact of erosion on property and the environment	• Develop and implement requirements for erosion and sediment control • The correct procedures for erosion control on new development sites enforced. • The number of unsealed road verges susceptible to erosion reduced. • The incidence of river and stream bank erosion reduced.
URBAN SALINITY	
Impact of urban salinity on property and the environment reduced.	• Promote solutions to the ongoing salinity problems in Mudgee
PROTECTION OF AQUATIC AND TERRESTRIAL HABITATS	
Ensure that the stormwater system does not impact on aquatic and terrestrial habitats	• Reduce weed infestation in creeks and riparian zones
ENSURE COMMUNITY HEALTH AND SAFETY	
Ensure that public health and safety is not compromised by the stormwater system	• Reduce the frequency of sewer surcharges by reconfiguring the drainage systems in older areas of town • Overcome safety problems with open drains through playground and park areas.
INCREASE COMMUNITY AWARENESS	
Community awareness, education and involvement in stormwater management to be improved.	• Implement public education programs to increase public awareness and ownership
OPTIMAL INFRASTRUCTURE PLANNING AND MANAGEMENT	

LONG TERM (Overriding Objectives)	SHORT TERM (Sub-objectives)
Ensure stormwater and other infrastructure is designed, planned and managed to reduce impacts on property, public health and the environment	• Improve maintenance of stormwater infrastructure. • Ensure that the SMP is compatible with other Management Plans.
LOCALISED FLOODING	
Ensure that stormwater does not inundate properties and roads.	• Minimisation of localised flooding by improving stormwater management and maintenance.

Table 5.2 on the following page demonstrates how the above listed objectives are linked to the identified values.

TABLE 5.2: VALUES and STORMWATER OBJECTIVES LINKAGES



5.1 STORMWATER MANAGEMENT FOR NEW DEVELOPMENTS

Stormwater management plays a crucial role during construction work. Usually large areas of bare soil exist and erosion commonly occurs during rain if the soil is not properly captured.

Stormwater management objectives for new developments will aid the Council and developers to minimise the impacts of new developments and redevelopments upon receiving waterways and to incorporate greater stormwater management opportunities into new developments. They also provide a clear guidance to the development industry and the broader community as to what stormwater outcomes Council requires for new development to protect or restore the values of the catchment.

For each phase of development, stormwater management should focus on both, quantitative and qualitative objectives for stormwater control.

5.1.1 Stormwater Management Objectives – Construction Phase

The main issue during the construction phase is that of erosion from exposed soil, leading to elevated levels of suspended solids and turbidity in stormwater discharges. The following table provides a list of objectives, to which Council is committed, for construction phases for new developments.

Table 5.3: Construction Phase Stormwater Management Objectives for New Developments

Pollutant/Issue	Soil Type	Management Objective
Quantitative Objectives – for subdivisions and medium-large scale developments		
Suspended solids and turbidity	Dispersible, Fine	Suspended solids concentration not to exceed 50 mg/L for all 5-day rainfall totals up to 75th percentile rainfall event.
	Coarse	Suspended solids concentration not to exceed 50 mg/L for all flow events up to 25% of the 1 year ARI flow.
Qualitative Objectives – for all new developments, including individual building lots		
Suspended solids (sediment)		Minimise soil erosion and the discharge of sediment by the appropriate design, construction and maintenance of erosion and sediment control measures. Employ all practical measures to minimise soil erosion and the discharge of sediment in storms specified under Quantitative Objectives above.
Motor Fuels, Oils and other Chemicals		All motor fuels, oils and other chemicals are stored and used on site in a manner which ensures no contamination of stormwater
Litter		No litter in a position where it may blow or washed off-site.

Adapted from the Example SMP, EPA (1999)

For detailed information on erosion , concrete slurry, pesticides and litter control refer to Appendix E.

5.1.1 Stormwater Management Objectives – Post Construction Phase

Quantitative Objectives

Control techniques differ for each development, depending on the type of stormwater pollutants generated and the significant quantities. The following table ranks pollutants in terms of significance that are generated by different land uses.

Table 5.4: Ranking of Pollutants for New Developments

Development Style	Litter	Coarse Sediment	Fine Particles	Total P	Total N	Hydrocarbons, motor fuels, oils & grease
Low Density Residential	Y	N	N	Y	Y	N
High Density Residential	Y	Y	Y	Y	Y	?
Commercial, Shopping & Retail Outlets	Y	Y	Y	N	N	N
Industrial	Y	Y	Y	?	?	Y
Fast Food Outlets & Restaurants	Y	N	N	N	N	?
Carparks, Service Stations and Wash Bays	Y	Y	Y	N	?	Y

Adapted from the Example SMP, EPA (1999)
Y = key pollutant, needs to be addressed
? = variable, requires site-specific assessment
N = not significant

Table 5.5 describes a number of pollution retention to be achieved for specific pollutants. Table 5.6 lists Qualitative Post-Construction Phase Stormwater Management Objectives.

Table 5.5: Quantitative Post-Construction Phase Management Objectives for New Developments

Pollutant/Issues	Retention Criteria
Quantitative Objectives – applicable to subdivisions and all medium-large scale developments	
Coarse Sediment	80% of average annual load for particles 0.5mm or less.
Fine Particles	50% of average annual load for particles 0.1mm or less.
Total Phosphorus	45% retention of average annual load.
Total Nitrogen	45% retention of average annual load.
Litter	70% of average annual litter load greater thatn 5mm.
Hydrocarbons, motor fuels, oils and grease	90% of average annual pollutant load.

Adapted from the Example SMP, EPA (1999)

Table 5.6: Qualitative Post-Construction Phase Stormwater Management Objectives for New Development

Pollutant/Issue	Management Objective
Qualitative Objectives – applicable to all new developments	
Runoff volumes and flow rates Stormwater quality	• Impervious areas connected to the stormwater drainage system are minimised. • Reuse of stormwater for non-potable purposes maximised. • Use of vegetated flow path maximised • Use of stormwater infiltration 'at source' where appropriate.
Riparian Vegetation and Aquatic Habitat	Protect and maintain natural wetlands, watercourses and riparian corridors. All natural (or unmodified) drainage channels within the site which possess either: (a) baseflow (b) define vegetation (c) riparian vegetation
Flow	Alterations to natural flow paths, discharge points and runoff volumes from the site are to be minimised. The frequency of bank-full flows should not increase as a result of development. Generally, no increase in the 1.5 year and 100 year peak flows.
Amenity	Multiple use of stormwater facilities to the degree compatible with other management objectives.
Urban Bushland	Impact on stormwater discharges on urban bushland areas minimised.

Adapted from the Example SMP, EPA (1999)

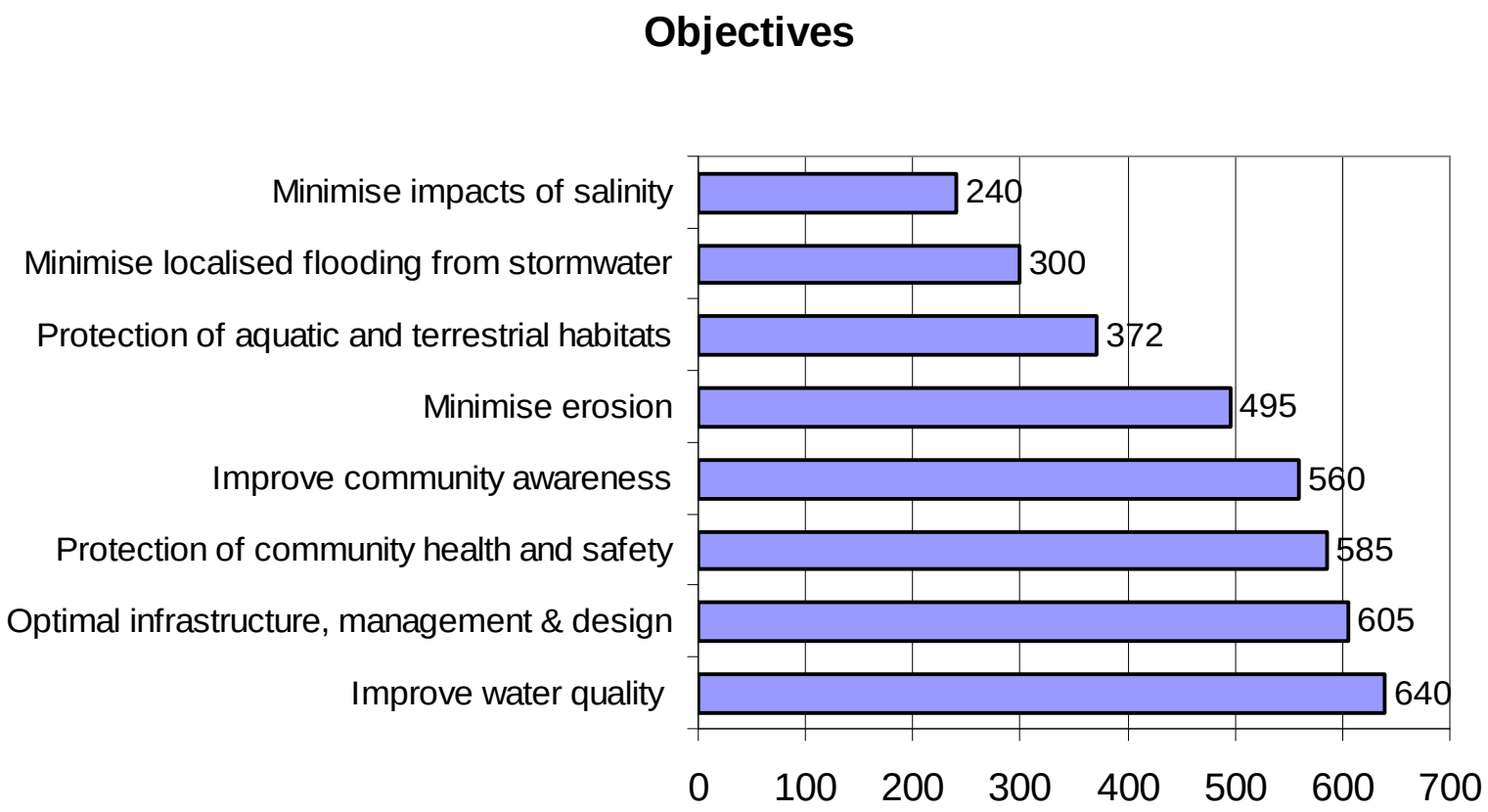
5.2 STORMWATER OBJECTIVES RANKING

Table 5.7 shows the objectives score allocations, which were derived from Table 5.2. The objectives were also ranked in descending order. The higher an objective is ranked the more values it addresses. Figure 5.1 is a graphical representation of the objectives scores.

Table 5.7: Scoring and Ranking of Objectives

Objective	Score	Rank
Improve water quality	640	1
Optimal infrastructure, management & design	605	2
Protection of community health and safety	585	3
Improve community awareness	560	4
Minimise erosion	495	5
Protection of aquatic and terrestrial habitats	372	6
Minimise localised flooding from stormwater	300	7
Minimise impacts of salinity	240	8

Figure 5.1: Objectives Ranking



6 – STORMWATER MANAGEMENT ISSUES

Issues can be defined as:

Factors that may inhibit our ability to meet our stormwater objectives at present or in the future.

The identification of stormwater management issues involved a review of existing information, field inspection and discussion with various State Government Agencies, community representatives and Council staff. Issues may be of social, economic, environmental and managerial origin.

Table 6.1 is a list of issues and possible causes that were raised by the stakeholders prior to the workshops. This table was further developed during the workshop session. These issues were then ranked by the independent facilitators. To rank issues, scores were derived from the impact of issues on stormwater objectives.

The issue-ranking scheme was done with the aid of a matrix, technically known as a frequency and impact study. Techniques of this type are widely used in the water industry where managers and stakeholders are faced with considering the importance of events and issues. This methodology primarily focuses on each issue and how it may impact on stormwater values and objectives in terms of probability and consequences. The way to do that is to look at:-

- the frequency with which an event occurs;
- the impact of the event on the environment.

Refer to Section 6.1 for an illustration of the issues ranking methodology. The issues were put into broader topics in the matrix for simplicity, rather than considering each issue individually from Table 6.1. The outcomes of the issues ranking with the aid of the matrix are shown in Table 6.5. A photographic record, showing examples of the issues highlighted by stakeholders and through catchment inspections is included in Appendix A.

Table 6.1: STORMWATER ISSUES IN MUDGEE AND GULGONG

SHORT TERM OBJECTIVE	ISSUE	CAUSES	LOCATION
ENVIRONMENTAL			
The amount of bacterial contamination due to sewer surcharges reduced	Bacterial Contamination	• Animal Droppings • Sewer Overflows	• Catchment Wide • Particularly in North-Eastern Mudgee (Market, Mortimer & Lawson St area)
Implement public education programs to increase public awareness and ownership	• Elevated Nutrient Levels • Pesticides	• Overfertilisation of lawns/gardens • Domestic animal and livestock droppings • Phosphate use near waterways • Detergents from car washing in streets • Fertiliser use on ovals/fields • Overuse of pesticides on household and council lands.	• Area wide • Wetland area in Gulgong
The amount of litter entering waterways reduced	Litter	• Lack of awareness • Apathy • Lack of trash racks	• Commercial area • Roadsides • Carparks • Around river outlets
Develop and implement requirements for erosion and sediment control	Turbidity	• Erosion in upper catchment	• Around river outlets after rain
Reduce the risk of contaminated run-off entering waterways from the industrial area	Industrial Pollution	• Contaminated sites • Flooding from Redbank Creek in Industrial area • Grease and Oil runoff from Service Stations	• Old Gas works at Court & Mortimer St • Sydney Rd Industrial area • Gulgong and Mudgee

SHORT TERM OBJECTIVE	ISSUE	CAUSES	LOCATION
The incidence of river and stream bank erosion reduced	Streambank erosion	• Clearing of vegetation • High flows	• Redbank Creek between Dam and Golf Course • Around outlets in Lawson Park and Gulgong
The number of unsealed road verges susceptible to erosion reduced	Roadside erosion	• Unsealed road shoulders	• Area wide
The correct procedures for erosion control on new development sites enforced	• Erosion from new developments • Increased problems with new development	• Clearing of new subdivisions • Lack of erosion and sediment control • Stormwater management not considered with new developments.	• New subdivisions, particularly in South and West Mudgee • New subdivisions
Reduce weed infestation in creeks and riparian zones	• Riparian Habitat • Weeds	• Increased stormwater flows affect riparian habitat of platypus and water rats. • Willows and Blackberry	• Cudgegong River • Redbank Creek
SOCIAL			
Reduce frequency of sewer surcharges by reconfiguring the drainage systems in older areas of town reduced	• Sewer Surcharges • Sewer overflows	• House stormwater drains connected to sewer overloading system during rain. • Old houses still have stormwater connected to sewerage system	• Lawson Park • Older parts of town (Market, Mortimer & Lawson St) • Older parts of town (Market, Mortimer & Lawson St)
Overcome safety problems with open drains through playground and park areas	Open drains	• Open drains through properties, near playgrounds • Open box culverts	• South Mudgee • Near Skate Park at Victoria Park • North Mudgee • Cudgegong Valley Public School

SHORT TERM OBJECTIVE	ISSUE	CAUSES	LOCATION
Implement public education programs to increase public awareness and ownership	• Car washing in street • Over fertilising • Using RoundUp on channel banks • Litter • Disposal of grass clippings	• A lot of messages, but they don't seem to get through	• Area wide
MANAGERIAL			
Minimisation of localised flooding by improving stormwater management and maintenance	• Inundation of properties • Localised flooding	• Inadequate kerb and gutter system causes • Hydraulic capacity of roadside drainage • Lack of Basic Stormwater Infrastructure to reduce nuisance flooding.	• Denison St • Dewhurst Dr • South Mudgee • Substantial areas of Mudgee and Gulgong
Improve maintenance of stormwater infrastructure	• Lack of maintenance • Old rubble pits not adequate for flows • Lack of space for major stormwater treatment options • Timing of Church St upgrade works • Litter • Overwatering of parks	• Erosion around kerb inlets • Lack of interlot drainage • Urban development close to creeks and river • Should be put off until SMP completed • Lack of trash racks/ maintenance of facilities • Inappropriate amount/timing of watering on parks	• Rouse St, Gulgong • Old areas of Mudgee • Particularly north of Short St. • Church St • Area wide
Promote solutions to the ongoing salinity problems in Mudgee	Urban Salinity	• Vegetation Clearing • Over-irrigation • Illegal bores irrigating gardens with salty water	• Mudgee • South Mudgee
Ensure that the SMP is compatible with other Management plans	Sediment and erosion control	• Lack of council plan • Lack of training	• Road and other maintenance works

Table 6.2 demonstrates how each of the issues is linked to one or more objectives, that is, they prevent us from achieving these objectives. This is how we arrive at the issues score. Figure 6.1 is a representation of the issues scores resulting from the links to objectives. The issues matrix in Figure 6.2 illustrates the relative importance of each issue when frequency of the issue is taken into account. For a detailed description of this process, refer to Appendix I.

TABLE 6.2: ISSUES - OBJECTIVES LINKAGE TABLE

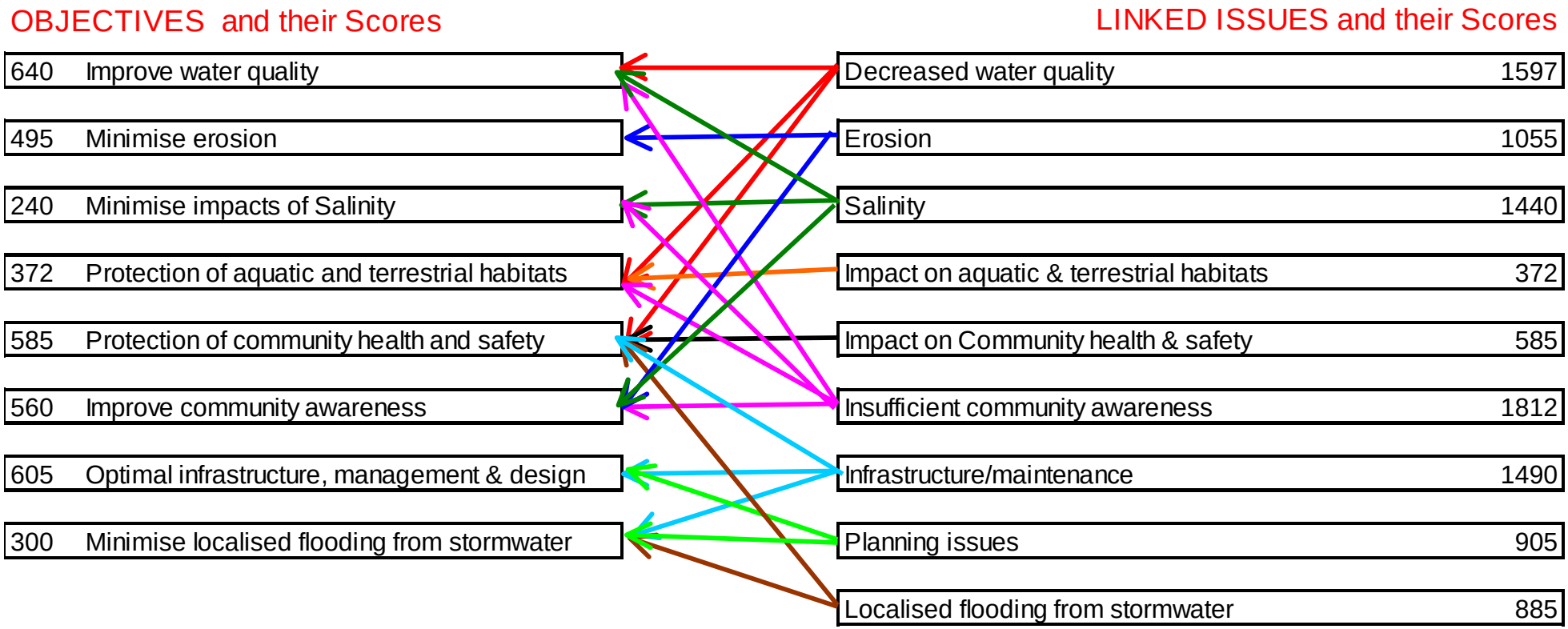


FIGURE 6.1: ISSUES RANKING FOR MUDGEE

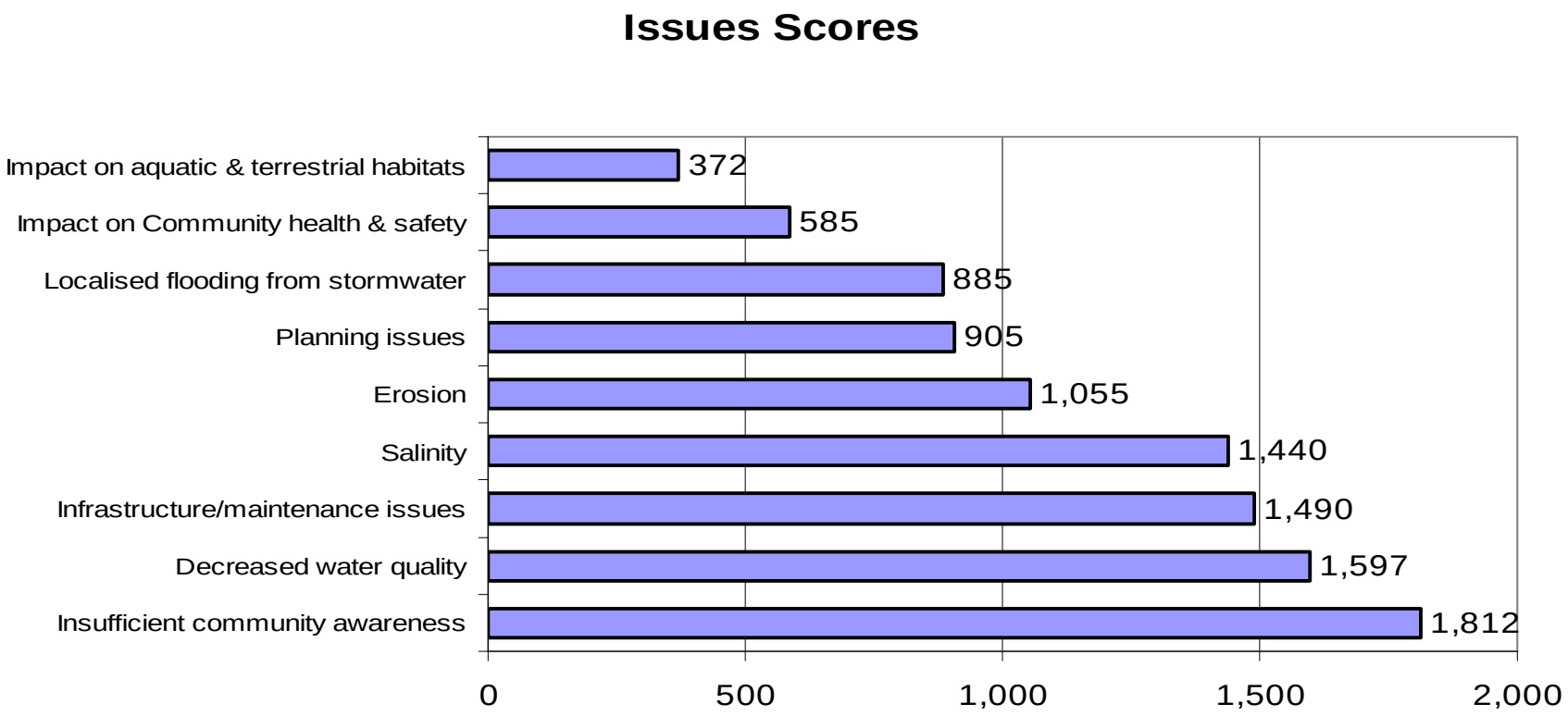
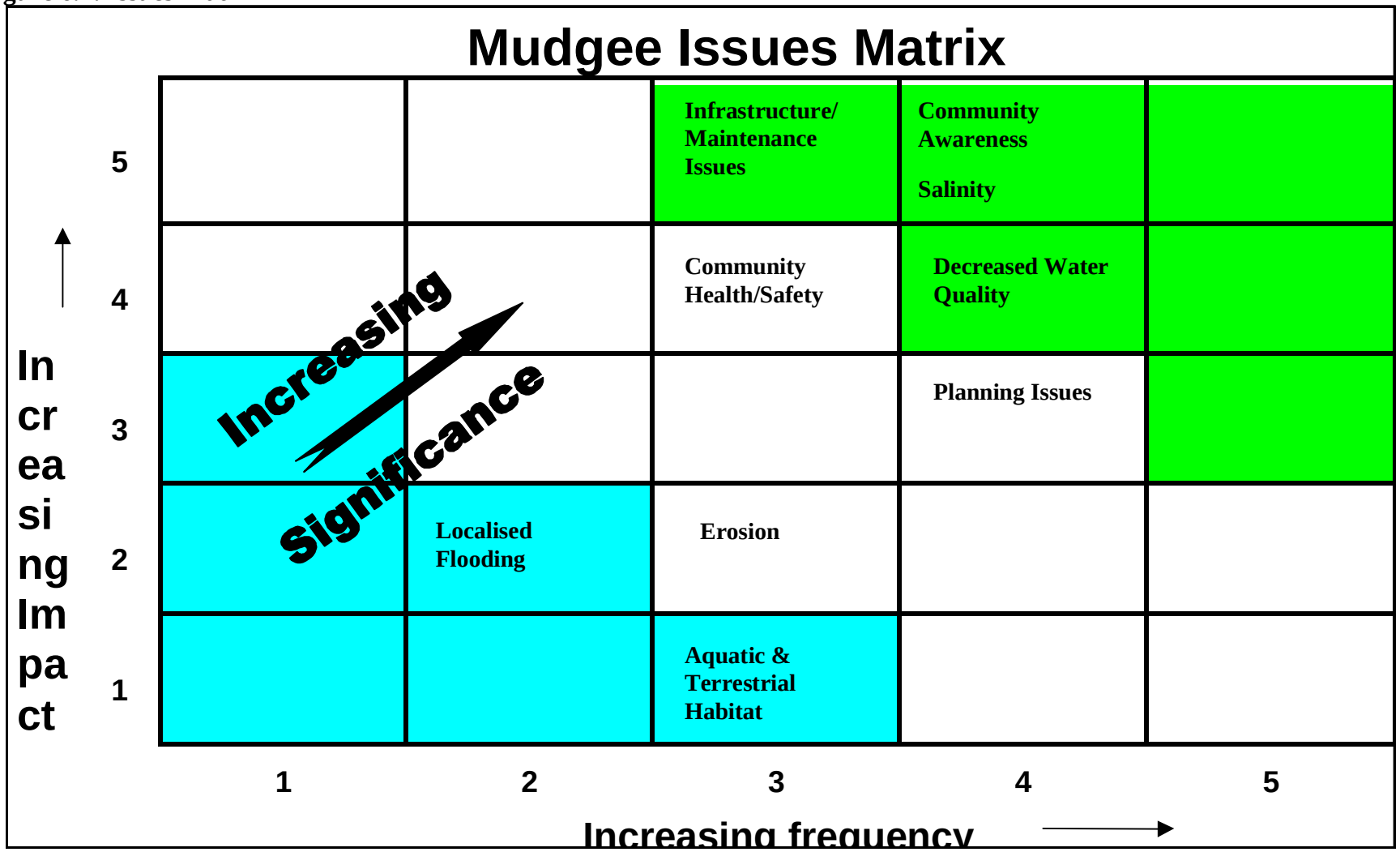


Figure 6.4: Issues Matrix



The above figure indicates that insufficient community awareness and salinity ranked highest in Mudgee and thus has most impact on stormwater values and objectives in the area.

7 – STORMWATER MANAGEMENT OPTIONS

Draft Management Options were developed by the facilitator in co-operation with Mudgee Council, Hunter Water Australia and other stakeholders. Options were linked to stormwater issues and objectives (Table 7.1).

Options aim at addressing the stormwater issues

Options were further examined by the stormwater managers because they are in a position to put a cost and practicality judgement against each of them. The management strategy should incorporate flexibility into the stormwater system and encourage best management practices in stormwater management.

7.1 ASSESSMENT OF OPTIONS

To evaluate stormwater management options, the following criteria are used:

1. An assessment of the efficiency of the option in meeting the stormwater objectives and addressing the key issues.
2. The likely impact of the option on residents and the community.
3. The estimated cost of the option (capital and operating, including maintenance).

7.2 COST-BENEFIT ANALYSIS

The cost-benefit analysis is conducted by placing options on a cost-benefit matrix. The scoring for each option is taken from Table 7.2. The cost-benefit analysis aims at providing Council with a list of practical stormwater management options. This includes an outline of costs for each option, scores from issues and the likely impact on the community (Table 7.2). Both the scores and the cost were used to place options in the cost-benefit matrix as shown in Table 7.3. From this, the stormwater managers can establish an order of priority when implementing stormwater management options to best satisfy community needs and to allow for a management plan that is feasible and effective.

7.3 OPTIONS SELECTION

A number of options are listed in Table 8.1. These options are of two general types:

- Non-structural
- Structural

7.3.1 Non-structural Options

These include:

- Education programs (eg. workshops, Streamwatch)
- Planning controls (eg. Council policies and strategies)
- Site auditing (eg. control of landuse)
- Review of management practices (eg. Council maintenance activities)
- Studies & assessments (eg. water quality monitoring)

7.3.2 Structural Options

These include:

- Litter traps (eg. litter baskets, litter booms, nets, litter socks, GPT, CDS)
- Sediment traps

- Constructed stormwater wetland
- Bank/river stabilisation (eg. removal of exotics, replanting of riverbanks with native species, grass lining of roads, rock walls, reno mattresses, concrete lining)
- Sand filters
- Basic drainage infrastructure to reduce incidence of nuisance flooding
- Provide inter-allotment drainage to help reduce salinity in the older areas of the town.

For detailed information on non- structural and structural stormwater management options refer to Appendices G and H.

Table 7.1 lists a number of potential options for each stormwater issue and 'hotspots'. The option list was developed with a close focus on issues and hotspots. An option that addresses more than one issue is favoured over an option that only addresses a single issue.

TABLE 7.1: ISSUES & OBJECTIVES AND THEIR LINK TO OPTIONS

ISSUE	CAUSES	LINK TO OBJECTIVES (FROM Table 5.1)	SCORE OF ISSUES (FROM Table 6.2)	OPTIONS
DECREASED WATER QUALITY				
• Elevated Nutrient Levels • Bacterial Contamination • Litter • Turbidity • Pesticides • Industrial Pollution	• Overfertilisation • Animal droppings • Detergents • Sewer overflows • Lack of awareness • Apathy • Lack of infrastructure • Erosion • Pesticide use • Contaminated sites • Service stations	• Water Quality • Aquatic habitats • Health & Safety	1597	**1.** Community Education **2.** Construct GPT/Litter traps to catch litter from commercial area (CDS Unit prior to major outlet at Lawson Park) **3.** Convert showground detention basin to wet retention basin/wetland **4.** Upgrade sewer connections, esp. in older areas of town **5.** Develop and enforce erosion controls **6.** Develop a trade waste policy to deal with pollution from industrial areas
EROSION				
• Streambank erosion • Roadside erosion • New Development sites	• Clearing of riparian vegetation • Unsealed road shoulders • Increased flows • Clearing for subdivisions • Lack of erosion and sediment control	• Erosion • Community awareness	1055	**7.** Riparian revegetation programs **8.** Vegetation of road shoulders **9.** Develop and enforce erosion and sediment control requirements for new developments **10.** Council to develop internal sediment and erosion control procedures and training
AQUATIC AND TERRESTRIAL HABITATS				
• Riparian habitat • Weeds	• Increased flow velocities • Willows, blackberry	• Protection of habitats	372	**11.** Promotion of on-site Stormwater detention to reduce peak flows **12.** Continue with weed eradication and revegetation programs

ISSUE	CAUSES	LINK TO OBJECTIVES (FROM Table 5.1)	SCORE OF ISSUES (FROM Table 6.2)	OPTIONS
HEALTH & SAFETY				
• Sewer Surcharges • Open channels & culverts	• Stormwater connections to sewerage system • Open structures near playgrounds	• Protection of health & safety	585	**13.** Upgrading of stormwater/sewer connections **14.** Restrict access to open drains identified as safety risks
LACK OF COMMUNITY AWARENESS				
Examples: • Car washing in streets • Overfertilising of gardens • Pesticide use • Litter • Grass clippings	• Messages don't seem to get through • Apathy	• Water Quality • Salinity • Habitat • Community awareness	1812	**15.** Develop and implement community education programs such as: • Streamwatch • Drain stencilling • Newspaper stories/advertising • Community programs
PLANNING ISSUES				
• Interlot drainage • Sewer overflows • New development • Lack of space for major treatment options	• Stormwater management not considered in planning decisions • Old infrastructure inadequate	• Infrastructure management • Localised flooding	905	**16.** Develop stormwater management requirements for new developments **17.** Upgrade old infrastructure and provide infrastructure where none exists **18.** Improve interlot drainage **19.** Alter design of existing detention basin to convert to a wet retention basin/wetland.
FLOODING				
• Localised flooding	• Hydraulic Capacity of roadside drainage	• Localised flooding • Health and Safety	885	**20.** Upgrade drainage capacity in identified problem areas identified in section 3.7 **21.** Promote on-site stormwater detention to reduce peak flows.
SALINITY				

ISSUE	CAUSES	LINK TO OBJECTIVES (FROM Table 5.1)	SCORE OF ISSUES (FROM Table 6.2)	OPTIONS
• Urban salinity	• Vegetation clearing • Over-irrigation • Illegal bores irrigating gardens with saline water	• Water Quality • Salinity • Community Awareness	1440	**22.** Promote revegetation of domestic and council properties with native species **23.** Enforce controls on bores **24.** Develop salinity management program to investigate the problem and develop a range of options.
INFRASTRUCTURE/MAINTENANCE/MANAGEMENT				
• Nutrients • Lack of maintenance of infrastructure • Litter • Overwatering of parks • Sediment and erosion control	• Fertiliser use on parks • Difficult maintenance of old/heritage infrastructure such as cobbled drains • Lack of trash racks/street sweeping/maintenance • Lack of in-house erosion and sediment plan • Lack of training	• Community Health & Safety • Infrastructure management • Localised flooding	1490	**25.** Reduce fertiliser use on council's parks & gardens **26.** Plant low maintenance native species in parks & gardens **27.** Install gross pollutant trap such as a CDS Unit prior to the Lawson Park Outlet **28.** Install a gross pollutant trap in Mudgee Catchment C (Perry St) **29.** Develop erosion control plan for council's works department **30.** Develop environmental/stormwater training program for Council personnel.

EVALUATION OF POTENTIAL MANAGEMENT OPTIONS.

The evaluation of Potential Management Options has been undertaken by assessing:

- Estimated capital cost (including associated costs such as service relocations)
- Estimated operations and maintenance costs
- Effectiveness in addressing the issue, including the ability to address multiple issues
- Land take requirements
- Ability to complement other potential management practices
- Proportion of the problem/issue addressed by the option.
- Environmental impacts
- Technical and administrative viability
- Whether legal requirements are satisfied
- Consistency with policies on other related issues (eg public health)
- Expected community acceptance

RANKING SYSTEM

Use of a ranking system, as outlined in *Managing Urban Stormwater* (Council Handbook), was recognised as a valuable technique for allocating a priority to management options. Scores were allocated to the costs and benefits of identified options to determine a priority. Although this is a relatively simplistic and subjective process, it is transparent and avoids unstated assumptions.

The ranking methodology as outlined in *Managing Urban Stormwater* is described below, with the general description of the methodology being:

- Each option is assessed in terms of its costs and benefits
- All factors are assigned a score from 1 to 10
- The cost index is comprised of 2 and benefit index of 6 individual factors
- The costs factors are averaged and benefit factors are averaged to provide the cost and benefit indices
- The cost index is divided by the benefit index and multiplied by 10, to avoid decimals, to provide the cost benefit ratio
- The options are ranked (1 being the most desirable)

Other limitations of this methodology include:

- Some options do not readily lend themselves to this process
- Although an attempt has been made to identify the most important factors, no attempt has been made to include every possible factor
- The scores assigned to the benefit factors may be relatively subjective
- The scores assigned to the cost factors will probably be estimates only
- No attempt has been made to place weighting on the individual cost or benefit factors or the ratio between them (eg higher cost recommendations may be made more competitive by dividing the cost index by 2 or some other factor considered appropriate)

Table 7.2: Cost scores for Option Ranking Scheme

CAPITAL COSTS		OPERATIONS & MAINTENANCE COSTS (annual)	
Estimated Cost ($)	**Scoring**	**Estimated Cost ($)**	**Scoring**
<5,000	1	<5,000	1
5,000 – 10,000	2	5,000 – 10,000	2
10,000 – 15,000	3	10,000 – 15,000	3
15,000 – 20,000	4	15,000 – 20,000	4
20,000 – 30,000	5	20,000 – 30,000	5
30,000 – 40,000	6	30,000 – 40,000	6
40,000 – 50,000	7	40,000 – 50,000	7
50,000 – 70,000	8	50,000 – 70,000	8
70,000 – 100,000	9	70,000 – 100,000	9
>100,000	10	>100,000	10

As outlined in *Managing Urban Stormwater*, the potential benefits can be allocated a score for the estimated relative harm of the pollutant, number of pollutants targeted by the option and proportion of catchment addressed. The relative harm of pollutants category addresses the pollutants considered to be the most significant in urban stormwater and the corresponding scores are suggested by EPA based on their experience in a number of urban catchments. If the recommendation dealt with a number of pollutants, the highest score was used. The catchment proportion factor could be weighted in accordance with the relative proportion of the pollutant sources in the catchment targeted by the option, not just the physical area of the catchment.

Table 7.3: Benefit Scores for Ranking Option Scheme

Impact (from issues matrix)		Frequency (from issues matrix)		Proportion of catchment	
Issue	**Score**	**Frequency**	**Score**	**Area (%)**	**Score**
Water quality	4	Water quality	4	<10	1
Impact on habitats	1	Impact on habitats	3	11-20	2
Salinity	5	Salinity	4	21-30	3
Planning	3	Planning	4	31-40	4
Insufficient community awareness	5	Insufficient community awareness	4	41-50	5
Health and safety	4	Health and safety	3	51-60	6
Flooding	2	Flooding	2	61-70	7
Erosion	2	Erosion	3	71-80	8
Maintenance	5	Maintenance	3	81-90	9
				91-100	10

Following ranking sheets present management options and associated costs, benefits and ranking for each option.

Table 7.4 – Options Analysis

OPTION	COSTS			BENEFITS							RANK	
Refer to Table 7.1	Capital	Operating	Cost Index	Impact	Frequency	% of catchment targeted	Effective-ness	Land take requirements	Community education value	Benefit Index	Cost /Benefit Ratio	Ranking
15. Develop and implement an integrated community stormwater education program. (Major issue: Community Awareness)	3 $10,000	1 <$5,000 per annum	2	5	4	10	8	10 No land-take requirements	10	7.83	0.26	3
27. Install CDS Unit upstream of main SW outlet in Lawson Park (Major issue: Water Quality)	9 $70,000 - $80,000	2 $5,000-$10,000 per annum	5.5	4	3	3	8	9 Land is under the control of Council	6	5.33	1.03	13
3.Convert Showground detention basin into a wet retention basin/wetland (Major issue: Water Quality)	7 $40,000 - $50,000	2 $5,000 - $10,000 per annum	4.5	4	3	3	8	9 Land is under the control of Council	10	6.17	0.73	11
13. Remove stormwater connections to sewer in older areas of town Major issue: (Community Health & Safety)	10 >$200,000	1 <$5,000 per annum	5.5	4	3	1	8	10 No land take requirements	7	5.5	1	12

OPTION	COSTS			BENEFITS							RANK	
Refer to Table 7.1	Capital	Operating	Cost Index	Impact	Frequency	% of catchment targeted	Effective -ness	Land take requirements	Community education value	Benefit Index	Cost /Benefit Ratio	Ranking
10. Council to develop an erosion and sediment control plan (Major Issue: Erosion)	2 $5,000 - $10,000	1 <$5,000 per annum	1.5	2	3	6	8	10 No land take requirements	4	5.5	0.27	4
9.Enforce erosion controls on new developments (Major issue: Erosion)	1 <$5,000	3 $10,000 - $15,000 per annum	2	2	3	3	8	10 No land take requirements	8	5.67	0.35	7
6.Develop a trade waste policy and system to deal with pollution from industrial areas (Major issue: Water Quality)	2 $5,000 - $10,000	3 $10,000 - $15000 per annum	2.5	4	4	1	8	10 No land take requirements	6	5.5	0.45	9
12. Continue weed removal and riparian revegetation programs (Major issue: habitat)	2 $5,000 - $10,000	2 $5,000 - $10,000 per annum	2	1	3	2	8	5 Some private properties affected	8	4.5	0.44	8
8.Vegetate unsealed road shoulders (Major issue: Erosion)	9 $70,000 - $100,000	4 $15,000 - $20,000 per annum	6.5	2	3	3	6	9 Land is under control of Council	8	5.17	1.26	15

OPTION	COSTS			BENEFITS							RANK	
Refer to Table 7.1	Capital	Operating	Cost Index	Impact	Frequency	% of catchment targeted	Effective -ness	Land take requirements	Community education value	Benefit Index	Cost /Benefit Ratio	Ranking
21. Promote on-site stormwater detention to reduce peak flows (Major issue: localised flooding)	1 <$5,000	1 <$5,000 per annum	1	2	2	8	8	10 No land take requirements	10	6.67	0.15	2
14. Construct barriers to restrict access to open drains identified as safety risk (eg. next to skate park) (Major issue: health & safety)	2 $5,000 - $10,000	1 <$5,000 per annum	1.5	4	3	1	8	9 Land is controlled by Council	8	5.5	0.27	4
16. Implement a Development Control Plan for stormwater management requirements for new developments (Major Issue: Planning)	3 $10,000 - $15,000	1 <$5,000 per annum	2	3	4	2	8	10 No land take requirements	8	5.83	0.34	6
18. Improve interlot drainage in older areas of town (Major Issue: Planning)	10 >$100,000	1 <$5,000 per annum	5.5	3	4	2	6	5 Affects Private Properties	7	4.5	1.22	14

OPTION	COSTS			BENEFITS							RANK	
Refer to Table 7.1	Capital	Operating	Cost Index	Impact	Frequency	% of catchment targeted	Effective -ness	Land take requirements	Community education value	Benefit Index	Cost /Benefit Ratio	Ranking
20. Upgrade drainage capacity in identified problem areas such as Dewhurst Dr, South Mudgee (Major Issue: Localised Flooding)	10 >$100,000	2 $5,000 - $10,000 per annum	6	2	2	1	5	9 Land is controlled by Council	4	3.83	1.57	16
22. Promote revegetation of properties with native species to lower water table and reduce salinity (Major Issue: Salinity)	1 <$5,000	1 <$5,000	1	5	4	8	8	9 Affects private property	10	7.33	0.14	1
23. Investigate and enforce removal of illegal bores (Major issue: Salinity)	2 $5,000 - $10,000	2 $5,000 - $10,000 per annum	2	5	4	1	6	10 No land take requirements	8	5.67	0.35	7
24. Develop a Salinity Management Plan to strategically deal with the issue of salinity in Mudgee (Major Issue: Salinity)	3 $10,000 - $15,000	1 <$5,000 per annum	2	5	4	9	9	10 No land take requirements	6	7.16	0.27	4

OPTION	COSTS			BENEFITS							RANK	
Refer to Table 7.1	Capital	Operating	Cost Index	Impact	Frequency	% of catchment targeted	Effective -ness	Land take requirements	Community education value	Benefit Index	Cost /Benefit Ratio	Ranking
25. Review and alter Council's fertiliser use on parks & Gardens (Major Issue: Infrastructure management)	2 $5,000 - $10,000	1 <$5,000 per annum	1.5	5	3	3	8	10 No land take requirements	4	5.5	0.27	4
26. Plant low maintenance, native species in Council Parks & Gardens (Major Issue: Infrastructure Management)	4 $15,000 - $20,000	2 $5,000 - $10,000 per annum	3	5	3	3	8	10 No land take requirements	7	6	0.5	10
29. Develop an environmental/ stormwater training program for Council personnel. (Major Issue: Infrastructure Management/Maintenance)	3 $10,000 - $15,000	1 <$5,000 per annum	2	5	3	3	8	10 No land take requirements	7	6	0.33	5

8 – IMPLEMENTATION STRATEGIES

The following strategies have been developed from the management options in section 7.0 and these focus on source control, practicality and cost-effectiveness. The strategies take into account stormwater values and objectives described in Sections 4.0 and 5.0. After evaluation of options (Section 7.0), these options were translated into actions with accordance to budget, responsibility and timeframe, as outlined below.

The list of actions also includes an additional 'wishlist' of actions that Council would like to undertake if funding is available.

Table 8.1: Implementation Strategy

Option Refer Table 7.1	ACTIONS	ESTIMATED $ COST Capital	Operating	TIMEFRAME	COMMENTS
Actions to be implemented by Council					
COUNCIL ACTIONS					
1 and 15	Integrated Community Education Program	$10,000-$20,000	$5,000 p.a.	2001/2002	Includes options ranked 1, 2 & 3 from Table 7.4
24	Develop a Salinity Management Plan	$10,000 - $15,000	$5,000 p.a	2001/2002	Managing the salinity problem in Mudgee is beyond the scope of a Stormwater Management Plan.
14	Investigate safety risks of open stormwater channels and culverts and restrict access if necessary	$5,000-$10,000	<$5,000p.a	2001/2002	
12 and 7	Continue with riparian weed eradication and revegetation programs along the Cudgegong River and Redbank Creek		$5,000 - $10,000p.a	2001/2002	Continuation and expansion of a willow removal program already implemented by Council
5, 10 and 28	Council to develop and implement an erosion and sediment control plan	$5,000 - $10,000	$5,000 p.a.	2002/2003	
29	Environmental/ Stormwater Training for Council Personnel	$10,000 - $15,000	<$5,000p.a	2002/2003	Integrating erosion & sediment control, chemical use, grounds watering

Option Refer Table 7.1	ACTIONS	ESTIMATED $ COST Capital	Operating	TIMEFRAME	COMMENTS
9 and 16	Enforce Erosion and Sediment Control on New Developments/ Construction Sites	<$5,000	$10,000 - $15,000p.a	2002/2003	By implementing fines for non-compliance, this action could become partly self-funding
6	Develop a trade waste policy and management system to regulate discharges and pollution from industrial and commercial sites.	$5,000 - $10,000	$10,000 - $15,000	2003/2004	By implementing trade waste charges, this action could become primarily self funding.
25	Review fertiliser and water use on Council's grounds	$5,000	<$5,000	2003/2004	
8,22 and 26	Ongoing maintenance of parks and gardens to use low maintenance native species	$20,000		2003/2004	Will reduce maintenance requirements, leading to reduced impacts from pesticides, fertilisers and over-watering
Actions that Council could implement if funding is available					
COUNCIL ACTIONS					
2, 27 and 28	Install CDS Unit downstream of commercial area prior to outlet in Lawson Park and in Mudgee Catchment C (Perry St)	$150,000	$10,000	2001/2002	
3	Convert showground detention basin to a wet retention basin/wetland	$50,000	$10,000	2002/2003	This action will address numerous issues. Flood relief/detention will still occur, along with stormwater treatment. Planting of native wetland plant species will provide habitat.
	Implementation of the drainage improvements recommended by Lyall & Macoun (1998) and outlined in Section 3.7				Costs for these works will be determined in the more detailed investigation and design stages of the projects.

Note that there are no RTA actions in the implementation strategy.

Effective stormwater management should aim at an innovative, site-specific approach. An integrated approach is required to ensure effective implementation to maximise pollutant removal, minimise cost and reduce maintenance burdens.

Both deficiencies in current stormwater management practices and a guideline for future management and improvement of the stormwater system have been addressed in the implementation strategy.

This SMP will be reviewed on an on-going basis to ensure that actions are implemented and that actions do indeed improve stormwater management to the satisfaction of both the Council and the community. Regular meetings will aid as does the involvement of other groups such as Landcare, Rivercare and Total Catchment Committees, etc.

8.1 MANAGEMENT STRATEGY

The implementation plan aims at identifying areas of approval and the establishment of a monitoring and review phase. It will enable the Council to outline a financial program, identifying major capital investment time and cost. From the cost-benefit analysis it became evident that the management strategy should focus on the mitigation of identified high priority issues.

Council may also gain increased community support and participation through the establishment of a public information framework relating to stormwater issues and concerns within the Mudgee urban stormwater catchment.

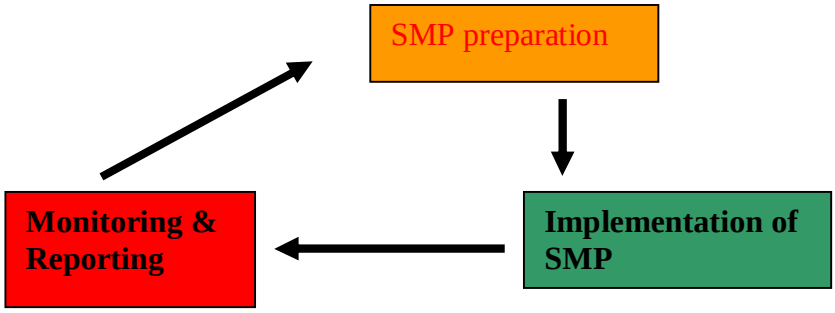
Appendix “G” is an expansion or explanation of some of the options mentioned earlier and will outline details of some of the possible options for Council to follow.

9 – MONITORING AND REPORTING

Revision of the Stormwater Management Plan is a crucial part in stormwater management plan to ensure its effectiveness in years to come. Environmental conditions and uses of the catchment will change over time and this SMP should be flexible to evolve with these changes. Council will link this plan to their Management Plan, which is being reviewed every 5 years. This plan usually only identifies options if funding is available to Council.

A typical stormwater management loop is illustrated in Figure 9.1.

Figure 9.1: Stormwater Management Loop.



The stormwater management loop shows how the preparation of the SMP, the implementation as per implementation strategy and the monitoring and review of the implementation measures all form part of stormwater management. This loop is continuous and needs to be updated on a regular basis.

Catchment management responsibilities will include:

1) Carrying out surveys on a regular basis to assess the health of the catchment, pollution sources and to identify problems (erosion, weeds, litter, etc)

2) Monitoring and reporting publicly on the performance of this Stormwater Management Plan regularly.

3) Provision of regular briefing to Council on progress against the Plan and developing more comprehensive objectives and targets for the Plan when significant monitoring has been completed.

9.1 MONITORING

Monitoring is an important tool in assessing the success of the Stormwater Management Plan. Monitoring should include water quality monitoring and should generally be undertaken in accordance with the principles outlined in the EPA's *Managing Urban Stormwater: Council Handbook* document.

Monitoring is a part of the urban stormwater management responsibility to determine if actions and strategies are effective. The overall objectives should include minimisation of environmental impacts in accordance with the principles of Ecologically Sustainable Development and Total Catchment Management.

Lack of monitoring and maintenance results in overgrown vegetation, accumulated sediment and debris, and deteriorated stormwater structures can greatly reduce effectiveness. Without maintenance on a regular basis, stormwater structures may not store, treat or convey stormwater according to design and purpose, and may require frequent repair or even replacement. Regular maintenance will allow structures to operate as designed for their maximum lifetime, enabling optimum flood control and water quality treatment as well as demonstrating to the community that stormwater capital investments are being protected in a systematic, responsible and cost-effective way.

The catchment health will be assessed and reviewed with the assistance of relevant community groups and Government agencies. For example, School and Landcare groups could be involved in observational water quality assessment, which is an effective tool in establishing the success of the Stormwater Management Plan. It is necessary to establish base line data and information on stormwater issues in Mudgee including photographic and water quality information.

The performance evaluation and reporting of the performance of the Urban Stormwater Management Plan will provide a review of recommendations and stormwater strategies so they remain valid and effective over time.

The review progress should be conducted on a regular basis against available base line data and against each objective.

Monitoring can be achieved through the following:

- observation based monitoring,
- ambient water quality monitoring,
- biological monitoring and recording progress of plan implementation.

9.1.1 Observational Monitoring

Mudgee Shire Council will implement observation based monitoring, which will be carried out by council staff on a monthly basis. Council staff will inspect stormwater outlets and drains throughout the urban areas. Information noted and recorded will include; Location, date, time, weather conditions, flow conditions, flow depth, and any stormwater issues observed. Issues that can be identified by using his observation based monitoring include:

- Litter
- Foam
- Algae
- Odour
- Water clarity
- Organic matter
- Aquatic plants
- Riparian vegetation
- Fish
- Erosion
- Sedimentation

Photos should also be taken for easy comparison of changes over time.

9.1.2 Water Quality Monitoring Program

Water quality monitoring will be carried out on an as need and opportunistic basis, as stormwater only remains in Mudgee for a short period of time. Water samples should be taken from sites within the urban catchment and also upstream and downstream of the urban areas in the Cudgegong River to ascertain the effect of urban run-off on the quality of the river.

The more water samples are collected, the better chance we have of understanding the status of the water quality, and thus leading to better ways to manage the water at a high quality level for residents.

Why do we monitor water quality?

Water-monitoring programs provide valuable data on the water quality of the catchment, establishes a bank of knowledge and understanding on the natural quality of water. By increasing the amount of reliable data, more accurate assumptions on the natural water quality can be made. In addition, the community will show that they are proactive in the management of the catchment and its natural resources. It also provides the community with an understanding of how different soils, or management practices can influence the quality of water.

A water quality sampling recording sheet might look like the following table.

Location	Colour	Turbidity (NTU)	pH	Total Phosphorus (mg/l)	Nitrogen (mg/l)
Upstream of the urban catchment					
Near major outlets into the river					
Downstream of the urban area					
Any other locations of concern					

Note: Downstream of one town is upstream of another town and impacts on water quality in one town may therefore effect towns further downstream.

Addition sampling may be done for:

- Faecal Coliforms
- Chlorophyll-a
- Conductivity
- Dissolved oxygen
- Temperature

Before commencing water quality sampling, the following need to be established:

- Baseline water quality conditions (eg. ANZECC Guidelines)

- Determine how to link monitoring and looking at the performance of the existing stormwater management practices (ie. Does the education program improve water quality?)

With time, Council should consider whether there are catchment wide changes in water quality as a result of structural and non-structural measures implemented as part of the SMP.

9.1.1 Biological Monitoring

Biological monitoring will help in the understanding of the health of waterbodies and involves the collection of marine and freshwater biota from the waterbodies. The aim is to build a picture of the waterbodies over time so that when changes occur, the type, magnitude and frequency of that change can be easily monitored and possibly linked to a specific cause or causes.

Biological monitoring will also be undertaken as needed.

9.2 MECHANISM FOR REPORTING

The process of the implementation of the SMP and monitoring results of stormwater quality will be included in the Council's State of the Environment Report and it should be used as a valuable input into future improvements of stormwater management. The effectiveness of pollution control devices needs to be highlighted to pinpoint any weaknesses of these and aid in improving its effectiveness.

9.3 PROGRAM FOR REVISION

This Plan will be reviewed on a regular basis. The revision process will involve the assessment of the effectiveness of stormwater management options (ie. Do options satisfy the stormwater management objectives?). The implementation strategy will aid Council in future management planning processes. Programs should also account for linking the stormwater implementation strategies to Council's management planning process (LG Act).

Revision can be undertaken in two different ways and timeframes:
(a) revise the implementation strategies
(b) review the SMP document

9.3.1 Revise Council Implementation Strategy

The implementation Strategy is the basis for Council's stormwater management program and addresses each stormwater issue within the catchment in a cost-effective and community-beneficial manner. The implementation strategy will be reviewed on an annual basis, as the budget for the following financial year is being considered and options to implement are being assessed.

The implementation strategy is dynamic and should evolve as stormwater works have been completed (and as issues have been addressed). New issues may arise and new strategies may need to be developed. The implementation strategies should be reviewed on an annual basis to identify progress and gaps in the program.

The review of the implementation strategy should consider:

- Results of any monitoring programs, ie. Water quality monitoring
- Any additional stormwater management option to be included in the plan

9.3.2 Review the SMP Document

Just as the implementation strategy is dynamic, objectives and issues are dynamic as well. The revision of the SMP is important to ensure that these are relevant and provide the necessary information for the Council's works program.

The revision should take place as required with the exception of the implementation strategy which should be revised more frequently. The review of the plan should involve:

- Results from any monitoring programs eg. water quality monitoring
- The effectiveness and efficiency of options implementation
- Document what objectives and issues have been addressed
- The effectiveness of satisfying the community's values
- Newly arising issues and objectives
- Improve the local understanding of issues within the catchment
- Identify if additional options need to be developed or if present options need to be modified

9.4 CONCLUSIONS

The preparation of this SMP was achieved through catchment inspections with Council, consultation of the community and agencies and the Council. This plan could not have been developed without the valuable local input from the stakeholders and the cooperation of Council. Effort has been put into this plan to ensure that community values and concerns have been included and supported by stormwater managers.

There are no universal fixes for stormwater pollution control. Each outfall and drainage basin must be analysed to determine types of pollution loadings, size of drainage basin, type of conveyance system, and pollutants targeted for removal. Then the appropriate Best Management Practise (BMP) strategy or strategies should be selected.

This Stormwater Management Plan for the Mudgee Local Government Area provides an integrated scheme for the ecologically sustainable and cost-effective BMP of stormwater within the area. The Plan will satisfy the community's expectations and address environmental issues. The major part of this plan is the implementation strategy, which defined actions to be implemented by Mudgee Shire Council to address stormwater issues and objectives. The implementation strategy also prioritises work in terms of its cost and benefit to the community

Addressing stormwater within the catchment requires a long-term commitment by Council and cooperation of the community. It should be noted that stormwater management is an integral part of catchment management.

REFERENCES

Bureau of Meteorology, 2001. Climate Averages for Australian Sites, [online]. Available: http://www.bom.gov.au/climate/averages/tables.htm [2001, May 28].

Lyall & Macoun Consulting Engineers, 1998. Gulgong and Mudgee Stormwater Drainage Studies

Mudgee Shire Council, 2000. Central West and Orana State of the Environment Report

Murphy, B.W and Lawrie, J.W, 1998. Soil Landscapes of the Dubbo 1:250,000 Sheet. Department of Land and Water Conservation of NSW, Sydney

NSW Environment Protection Authority, 2000. Water Quality and River Flow Interim Environmental Objectives – Macquarie-Bogan River, [online]. Available: http://www.epa.nsw.gov.au/ieo/MacquarieBogan/report.htm [2001, January 2].

APPENDIX A: PHOTOGRAPHIC RECORD

Photo 1. A small constructed wetland behind the Squash Centre on Short St, Mudgee

Photo 2. The creek downstream of the wetland. Erosion is a problem here, particularly from the outlet of the street drainage (Photo 3).

Photo 3. Erosion and debris around the street drainage outlet at the end of Court St, Mudgee

Photo 4. Erosion of the bank of the Cudgegong River, adjacent to the outlet in Lawson Park

Photo 5. Litter on the bank of the Cudgegong River at the outlet from the commercial area

Photo 6. Immediately downstream of the railway line behind the Mudgee industrial area, stormwater is transported by overland flows

Photo 7. Insufficient road maintenance can lead to roadside erosion, as seen here in Gulgong

Photo 8. Runoff from the forecourt of this service station in Gulgong flows straight into the stormwater system carrying pollutants such as oil.

APPENDIX B: CATCHMENT AUDIT PROTOCOL

MUDGEE Catchment Audit Protocol	
Is litter visible? ☐ ☐ Yes No describe	Yes, litter around fast food outlets
Is there evidence of erosion?	
Are weeds a problem?	Yes, Cudgegong River banks. Willow and blackberry
Is riparian vegetation effected by the outfalls?	Some erosion around outfalls
Check existing pollution devises (GPT's etc)	
Is the trap maintained on a regular basis?	
How often are traps cleaned?	
What quantity of rubbish is removed annually?	
Is the trap a potential mosquito breeding area?	
How does the trap cope with 1 in 5 year storms?	
Have there been any complaints regarding traps from the community?	
Are there plans to upgrade/replace/remove trap?	
Is council happy with the traps?	
Are there any animal scats near SW channels?	
Sewage Overflows	Lawson Park, root intrusion in old mains.
Is the overflow visible?	
Is there evidence of recent overflows?	
Have there been complaints about major overflows?	Fixed a lot of inflow problems-missing lids
How often do overflows occur from major overflow outlets?	
Do overflows enter sensitive waterways?	Cudgegong River
Has the overflow affected residents?	Bolted down a lot of manhole lids.
Is the EPA concerned about any overflow points?	
Have there been any environmental studies on the overflow's impact?	
Riparian Vegetation and Bushland	
Are there any significant areas of riparian vegetation in the SW catchment?	Only in upper catchment.
Is riparian vegetation affected by stormwater?	Erosion around outfalls
Does Council or any other group intend to restore any riparian vegetation?	No
Are there any areas of natural bushland within the urban catchment?	Yes – upper catchment
Have any areas of bushland been protected in a nature reserve/park etc.?	Yes
Does council (or other groups) intend to restore bushland?	
Industrial Areas	
Are there any industrial areas in the urban catchment/what types of industries?	Yes, mainly commercial/industrial.
Are there any proposals to expand existing areas?	
Has Council or other agencies carried out surveys of industrial areas?	
Are there any water quality problems associated with the industrial areas?	Possibly
Is there any evidence of industrial pollution in the SW system eg. discolouration/staining, dead flora and fauna downstream etc.?	No
Have there been any industrial waste incidents, how was it cleaned up, was contaminated waste removed?	

Where are trucks and other vehicles washed?	
What threats may be in the industrial area, e.g. acid, oils, metals, petrol, solvents	Hydrocarbons
Commercial Centre	
Is there evidence of pollution from commercial centres eg. litter, oil, etc.	Yes – litter
Are there any GPT's or silt traps in the SW system?	
Are there any GPT's fitted to any commercial premises?	
Are there any detention basins in the commercial area?	
Is there a need for GPT's, silt traps, additional rubbish bins or detention basins?	Possibly
Have there been complaints regarding litter from the commercial area?	
Are there any suitable locations for bins, traps, basins?	
What are the threats from the commercial area? eg. litter, oil, flooding etc.	Litter
Hotspots	
Are there any obvious erosion and siltation problems?	Yes
Are there any litter hotspots in the SW system?	Yes – shopping area
Are there any weed hot spots in the SW system?	Yes – all river bank and channels, esp. Redbank Creek
Are there any odour problem hot spots in the SW system?	
Are there any algae problems in the SW system?	No
Are there any mosquito breeding areas in the SW system?	
Are there any areas prone to animal waste problems e.g. horses, cattle, dogs etc?.	
Is there any localised flooding?	Yes, as shown on map

GULGONG Catchment Audit Protocol	
Is litter visible? ☐ Yes ☐ No describe	Yes, paper, plastic bags, PET bottles
Is there evidence of erosion?	
Are weeds a problem?	
Is riparian vegetation effected by the outfalls?	No
Check existing pollution devises (GPT's etc)	N/A
Is the trap maintained on a regular basis?	N/A
How often are traps cleaned?	N/A
What quantity of rubbish is removed annually?	N/A
Is the trap a potential mosquito breeding area?	N/A
How does the trap cope with 1 in 5 year storms?	N/A
Have there been any complaints regarding traps from the community?	N/A
Are there plans to upgrade/replace/remove trap?	N/A
Is council happy with the traps?	N/A
Are there any animal scats near SW channels?	
Sewage Overflows	New sewer system, not many problems.
Is the overflow visible?	
Is there evidence of recent overflows?	Some inflow problems
Have there been complaints about major overflows?	Overflowing pump stations
How often do overflows occur from major overflow outlets?	
Do overflows enter sensitive waterways?	
Has the overflow affected residents?	
Is the EPA concerned about any overflow points?	
Have there been any environmental studies on the overflow's impact?	
Riparian Vegetation and Bushland	
Are there any significant areas of riparian vegetation in the SW catchment?	No
Is riparian vegetation affected by stormwater?	No
Does Council or any other group intend to restore any riparian vegetation?	
Are there any areas of natural bushland within the urban catchment?	Not significant
Have any areas of bushland been protected in a nature reserve/park etc.?	
Does council (or other groups) intend to restore bushland?	
Industrial Areas	
Are there any industrial areas in the urban catchment/what types of industries?	Materials storage, vehicle maintenance.
Are there any proposals to expand existing areas?	No
Has Council or other agencies carried out surveys of industrial areas?	Yes
Are there any water quality problems associated with the industrial areas?	Needs to be more regulated, bunding etc
Is there any evidence of industrial pollution in the SW system eg. discolouration/staining, dead flora and fauna downstream etc.?	
Have there been any industrial waste incidents, how was it cleaned up, was contaminated waste removed?	
Where are trucks and other vehicles washed?	
What threats may be in the industrial area, e.g. acid, oils, metals, petrol, solvents	Solvents, nutrients, hydrocarbons

Commercial Centre	
Is there evidence of pollution from commercial centres eg. litter, oil, etc.	Yes – litter, oil, grease
Are there any GPT's or silt traps in the SW system?	No
Are there any GPT's fitted to any commercial premises?	No
Are there any detention basins in the commercial area?	No
Is there a need for GPT's, silt traps, additional rubbish bins or detention basins?	Possibly
Have there been complaints regarding litter from the commercial area?	
Are there any suitable locations for bins, traps, basins?	
What are the threats from the commercial area? eg. litter, oil, flooding etc.	Litter, oil, grease
Hotspots	
Are there any obvious erosion and siltation problems?	No
Are there any litter hotspots in the SW system?	Commercial area
Are there any weed hot spots in the SW system?	No
Are there any odour problem hot spots in the SW system?	No
Are there any algae problems in the SW system?	No
Are there any mosquito breeding areas in the SW system?	In the marshy areas where the stormwater discharges (north and west of town)
Are there any areas prone to animal waste problems e.g. horses, cattle, dogs etc?.	Rural areas downstream of urban area
Is there any localised flooding?	

APPENDIX C: STAKEHOLDER INVOLVEMENT

NAME	ORGANISATION	CONTACT NUMBER
Heath Carney	Hunter Water Australia	(02) 49799595
Malcolm Donnelly	Mudgee Shire Council	(02) 63725805
Jamie Lees	DLWC	(02) 63724044
Gerry Hennessey	NSW Agriculture	(02) 6724700
Bev Smiles	Mudgee Environment Group	(02) 63734330
Sue Clarke	WTS Environmental Laboratories	(02) 63726735
Amanda Paul	Mudgee Health Council	(02) 63722803
Carl Peterson	Mudgee Shire Council (Water and Sewerage section)	(02) 63725853
Anneke van Tholen		(02) 63726801
Fiona Harris		(02) 63727762
Ron and Deanne Berry		(02) 63726036
Greg Dolan	Fig Tree Retreat	(02) 63721132
Lesley Hails		(02) 63724152
Susan Fuller	Red Hill Environmental Education Centre	(02) 63726906
Christine McRae	Mudgee Urban Landcare	(02) 63737628

APPENDIX D: RESOURCES FOR IMPLEMENTATION AND LINK TO OTHER PLANNING DOCUMENTATIONS

To assists Council further in the implementation of the Stormwater Management Plans, a number of resource documents are available. These resources provide a guide into areas of stormwater management including source control techniques, construction activities, water sensitive urban design and treatment structures.

NSW Department of Housing (1998) Managing Urban Stormwater: Soils and Construction (3rd Edition)

The above document outline techniques for erosion and sediment control and protection of waterways, primarily during construction and new urban development. The documents include guidelines for on-site erosion control, and site rehabilitation after construction has been finalised.

NSW Environmental Protection Authority (1996) Managing Urban Stormwater: Treatment Techniques

This document outlines various structural treatment practices such as pollutant traps, wetlands and detention basins. The benefits and limitations of each technique are described along with other factors such as site constraints, to be considered in the selection of appropriate practices.

NSW Environmental Protection Authority (1998) Managing Urban Stormwater: Source Control (DRAFT)

Provides a guide to stormwater managers on a range of source control techniques that can be utilised to minimise the impacts on the stormwater environment. It provides guidance on choosing source controls, community education, Council activities such as maintenance and depot operations, urban land capability assessment and water sensitive urban design (WSUD) techniques.

NSW Environmental Protection Authority (1996) Solutions to Pollution: A Teaching and Learning Unit on Stormwater Issues (English Years 7-10)

NSW Environmental Protection Authority (1996) Solutions to Pollution: A Teaching and Learning Unit on Stormwater Issues (Science Years 9-12)

These educational units are targeted at high school students and aim to increase students' knowledge and understanding of the stormwater system and its link with

water quality in local waterways, and to lead students to adopt appropriate habits to protect water quality. The units outline classroom activities for Science and English students, such as the identification of sustainable and unsustainable catchment management practices and ways to keep waterways clean. A number of other educational materials are available from the EPA, and are listed on the Internet site -

http://www.epa.nsw.gov.au/pubslist.htm#water along with information about the EPA's "The drain is just for rain" education campaign
http://www.epa.nsw.gov.au/drain_rain

Allison, R.A, Chiew, F.H.S & McMahon T.A (1998) A Decision Support System for Determining Effective Trapping Strategies for Gross Pollutants. CRC for Catchment Hydrology Report 98/3

This is one of three reports that describe a gross pollutant research study undertaken by the CRC for Catchment Hydrology. The study aimed to provide an understanding of the quantities and characteristics of gross pollutants and to assess various trapping techniques. The decision support system provides a method for comparing different approaches for trapping gross pollutants. A computer model for the assessment of trapping techniques is provided with the report.

Other resources from the CRC's web-site are available at:
http://www.catchment.crc.org.au

APPENDIX E: EROSION CONTROL FOR NEW DEVELOPMENT SITES

Mudgee Shire Council is adopting the erosion guidelines as outlined in the "Urban Erosion and Sediment Control Field Guide" (prepared by the DLWC).

The following section is of particular relevance for new development sites. Often builders have limited space and therefore it may be difficult to develop full soil and water management programs. The following section is designed to help developers control:

- Erosion
- Concrete slurry, acid washes, paints, solvents, adhesives
- Pesticides
- Litter.

Pollutant	Description	Retention Criteria / Control Measures
Litter	All anthropogenic material eg. cans, bottles, wrapping materials, etc.	• 70% of objects 5o mm diameter or greater for flows up to 25% of the 1 year ARI peak flow
Sediments	Deposits including sand particles and soil	• Stockpiling material on site where possible and containing the material with a sediment fence • Covering the material to reduce the impact of wind and water • Gutter flow bypass with pipe laid in the gutter to convey water past the material • Install sediment fences
Coarse sediments	Coarse sand (<0.5 mm)	• Retention of sediments coarser than 0.125 mm for flows up to 25% of the 1 year ARI peak flow
Nutrients (mg/L):	Total phosphorus, Filterable phosphorus, Total nitrogen, Oxidised nitrogen, Ammonia	• 45% retention of the average annual load.
Oil & grease	(hydrocarbons)	In areas with concentrated hydrocarbon deposition, no visible oils for flows up to 25% of the 1 year ARI peak flow
Motor spirit and other pollutants	Concrete slurry, acid washes, paints, solvents,	Limit the application, generation and mitigation of toxic

Pollutant	Description	Retention Criteria / Control Measures
	adhesives, pesticides	substances to the maximum extent practicable
Suspended solids (SS)		80% retention of the average annual load
Fine particles	Fine grained clay	Maximising vegetation of bare soil

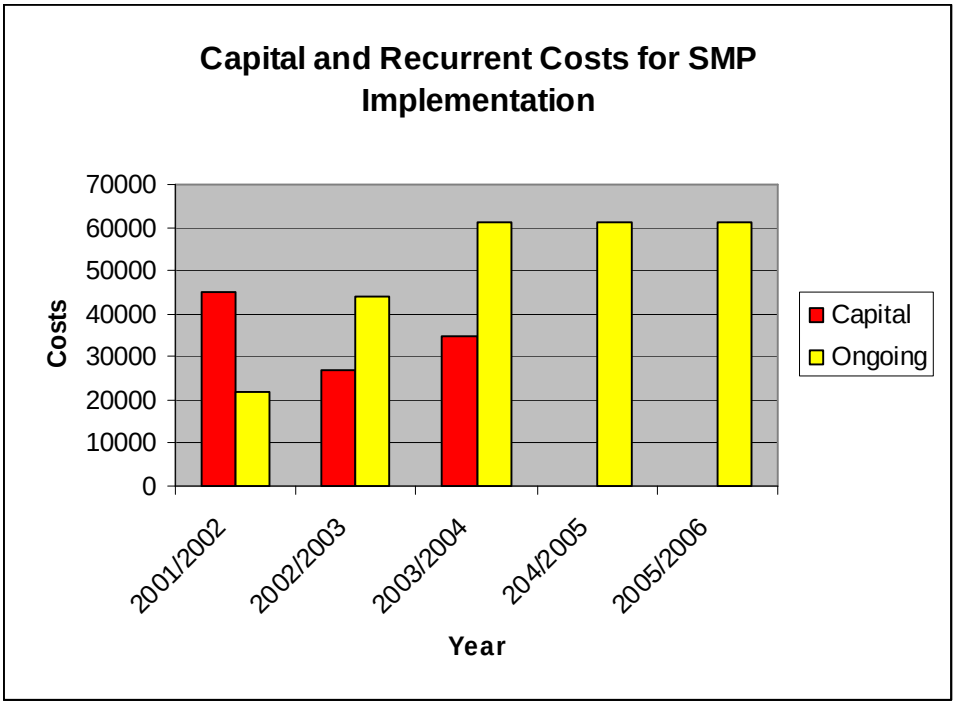
Where practical, larger (>2,500 square metres) developments should have SWMPs that outline strategies for protecting downslope areas from other pollutants. These strategies may require the design of water control ponds and/or wetlands. Show in the Plan the way that works will be modify the landscape and drainage pattens (adding new or modified existing constraints.

If possible, prepare the Plan at the design concept stage, taking consideration of design goals and based on an assessment of the physical constraints of the site.

For more detailed information refer to the NSW Department of Housing (August 1998) Managing Urban Stormwater: Soils and Construction (3rd Edn).

APPENDIX F: 5 YEAR EXPENDITURE

The following chart shows the proposed expenditure over a five-year implementation period. The red column shows the capital funding required, with the yellow representing ongoing costs. The ongoing costs continue to rise as ongoing costs from previous years are still incurred.



APPENDIX G: Community Involvement and Education

Community Involvement

Community education programs are implementation strategies to prevent, control and treat stormwater by observing substantial environmental improvements, realising economic advantages and enjoying various associated quality-of-life benefits. Community benefits may include aesthetics or recreational enhancement, overcoming administrative hurdles or institutional barriers, or improving community relations.

While many day-to-day activities impact on stormwater runoff, there are control strategies that work.

Polluted urban runoff can be prevented in a cost-effective response that comes from preventative, enforceable efforts that integrate all levels of government, design professionals from multiple disciplines, private organisations, and the local community. The following strategies have been proven effective in many stormwater cases:

- **Preserving and utilising natural features and processes** have many benefits. Undeveloped landscapes absorb large quantities of rainfall and vegetation helps to filter out pollutants from stormwater. Buffer zones, conservation design development, sensitive area protection, or encouragement of infill development all try to enhance natural processes and are among the most effective stormwater programs.
- **Strong incentives, routine monitoring and consistent enforcement to establish accountability** are the key element in improving water quality. Programs with high accountability can reduce pollutant loading by 50% or greater.
- **Establishing a dedicated source of funding ensures long term viability of programs and public support.** Dedicated funding sources, such as stormwater utilities or dedicated grants, help ensure that stormwater programs are stable over time and help gain public support.
- **Strong leadership is often a catalyst for success.** An individual is needed to champion the project and make it happen.
- **Effective administration is critical.** This allows implementation of broad-based, multi-faceted programs.

In summary, together the following summary key points build a strong framework for effective, efficient, and successful stormwater management over the long term.

- Plan in advance and set clear goals.
- Encourage and facilitate broad participation.
- Work to prevent pollution first, rely on structural treatment only when necessary.
- Establish and maintain accountability.
- Create a dedicated funding source.
- Tailor strategies to the region and setting.
- Build broad-based programs.
- Evaluate and allow for evolution of programs.
- Recognise the importance of associated community benefits.

Implement a Public Education Program

Public education is an important part in stormwater management. This action provides ownership to the community by informing the community about values of a healthy, well-maintained stormwater system. Public interest will be encouraged through education and ensured community involvement in the stormwater process. For example, leaves, grass clippings and organic matter from yards increase oxygen demands and may contribute nutrients to algae blooms that may result in fish kills. A significant source of nutrient input to water bodies is from grass clippings and leaves washed into drainage systems during storms.

The following are issues that should be addressed;

(a) Appropriate car washing:

- washing cars on lawns and not on roadsides or driveways
- prevent excess waste water from entering stormwater drains

(b) Appropriate litter disposal

- educate community about effects and consequences of inappropriate litter disposal
- outline correct litter disposal behaviour

(c) Appropriate waste oil and other chemical disposal

- ensure the community is aware of correct disposal for waste such as oil and other chemicals such as herbicides
- provide oil disposal facilities at service stations
- promote Hunter Water's free domestic chemical collection service

(d) Appropriate disposal of domestic animal droppings

- encourage dog walkers to implement correct disposal of dog droppings
- encourage appropriate disposal methods for households (compost bins, garbage bins, sewer)

(e) Appropriate garden and lawn maintenance

- correct levels of fertiliser use in gardens
- encourage use of low maintenance, native plant species
- discourage hosing lawn clippings from entering the stormwater gutters

(f) Safety awareness

- prevent contact with high velocity stormwater flows

Encourage Public Involvement in the Stormwater Management Process

Community involvement will provide a sense of ownership to the community and will aid the management of the urban stormwater system. The value of the stormwater system will be increased with the community's desire to maintain a healthy

stormwater system. Public involvement should be encouraged during all stages of the stormwater process, including planning, implementation and review stages.

Various programs such as Streamwatch and Landcare groups, school syllabus and community groups can be used to promote awareness and involvement of the community in managing and monitoring particular sections of the stormwater system.

Labelling of Stormwater Pits with Slogans

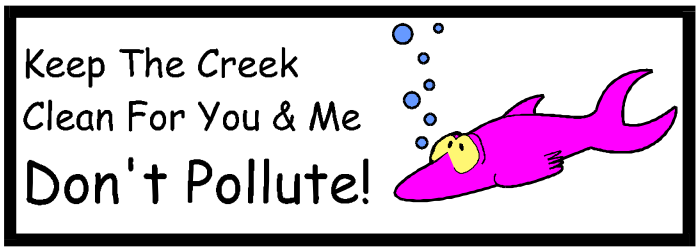
Stencilling labels near the stormwater pits with slogans such as

"Only rain down this drain"

The introduction of similar programs may encourage public awareness and decrease impacts of gross pollutants, grease and oils, nutrients and bacterial contamination. Local school, scouts and community groups may carry out the labelling with Broken Hill City Council supplying the road marking spray paint.

A program such as the Stormwater Industry Association (SIA) endorsed "Yellow Fish Road" Program could also be considered. This program, involving corporate sponsorship, combines drain-stencilling activities with distinctive yellow fish shaped fliers for letterbox drops. The program was first used in Canada and has been trialed and promoted by the SIA and Pittwater Council in Sydney.

STORMWATER DRAIN STENCILS



THE FOLLOWING INFORMATION WAS TAKEN FROM THE CITY OF FORT WORTH, TEXAS STORM DRAIN MONITORING PROGRAM
(http://ci.fort-worth.tx.us/dem/fishsign.htm)

STORM DRAIN MARKING PROGRAM
The installation of storm drain plaques has proven to be an effective means of providing a pollution prevention message to citizens.
Plaque Installation SOP

Materials
- Plaques.
- Wire brush (or steel wool).
- Cloth (or whisk broom).
- Paper towels/disposable rags.
- Adhesive (Liquid Nails) or waterproof silicone adhesive.

Procedure
- Determine location(s)

Criteria:
- On top or face of a storm drain curb inlet.
- Populated area or an area where dumping is suspected.
- Flat concrete surface.
- Clearly visible.
- Dry surface and warm temperatures.
- Once location has been determined, use the wire brush to clean the surface and wipe any debris away using a cloth or broom. Do not use water or cleaning agents.
- Apply adhesive to the plaque (do not apply directly on the concrete surface). Start from the outside edge and work inward to the centre.
- Place plaque on the cleaned and dusted concrete surface.
- Slowly step on top of the plaque being careful not to slide it around on the curb inlet. This will help secure the plaque to the concrete surface.
- Wipe away any excess adhesive with paper towels, if necessary.

Time
Typically, it takes approximately 5 minutes to install a plaque.

Precautions When Using Adhesives
- Before using any adhesive, read and follow all instructions on the tube.
- Eye protection and gloves are suggested. If gloves are not used, clean hands thoroughly after using adhesive.
- Adhesives release solvents when used, so use only in well-ventilated areas.
- Vapours released from adhesives are flammable, do not smoke while using the Liquid Nails.

Recheck
On occasion, check the placement location to make sure that the plaque has not been damaged or stolen.

Other Considerations
- Overuse of the plaques in one area will not only cause an area to look "tacky," but will cause people to grow accustomed to the plaques' presence and not pay attention to them.
- Use only on public right of way (street curb areas). Do not place plaques on private property.
- Respect a citizen's request to not install a plaque in front of their home.
- Wear a high visibility safety vest and do not stand or work in the street while installing plaques. Remember, safety first - it's dangerous out there!
- On Ozone Action Days, restrict plaque installations to the afternoon or wait until another day.

THE YELLOW FISH ROAD
Drain Marking Program
(abstract taken from the Waterfall Journal, Autumn 1999)
Using the outline of a silver bream, a common fish species in Australia, the outline will be stencilled on drains and used to shape a brochure, which will be letter-boxed to every home in the district. The shape of the bream will soon become synonymous with the clean drain program and hopefully stop the dumping of harmful waste into stormwater drains.

The aim of the Yellow Fish Road program is to remind people that it is marine life that ultimately bears the impact of what is washed down into the drains.

This program has been proven successful in Canada, and has really raised the awareness of the community to pollution discharging to receiving waters via stormwater drains. This program does work by reaching all age groups, reducing pollution loads, especially litter, waste oils and garden chemicals and fertilisers being washed into creeks, rivers, lakes and the sea.

The outcomes usually include most people becoming aware that stormwater from private properties and from roads and footpaths carries litter, oil, detergents, animal faeces and grass clippings through street drains directly to our beaches and waterways.

The Stormwater Industry Association or SIA (Local Government) is interested to receive submissions from Local Government and associated community groups who would like to join the Yellow Fish Road program. Organisations must be able to demonstrate that they can co-ordinate the campaign within their catchment or municipality and make the program part of their environmental education awareness approach to their community. Submissions should be made written to SIA and may be made at any time. Successful applicants will receive a sponsored Yellow Fish Road Kit.

Sponsor Package
Each Sponsor will be asked to pay for the following package.

- 5000 fish fliers
- 250 posters
- 500 bumper stickers

Each sponsor is asked to have an active involvement in the launch of the program in each district / catchment, and SIA and Local Government and community group would try and maximise the media publicity to reach local schools and residents.

STREAMWATCH
Streamwatch is a dynamic environmental action network, educating and empowering communities to work together for healthy catchments.

Streamwatch is supported by Department of Land and Water Conservation, Hawkesbury Nepean Catchment Trust, Hunter Catchment Management Trust, Sydney Water, Upper Parramatta River Catchment Management Trust, and Waterwatch Australia. In NSW Streamwatch operates under the umbrella of NSW WaterWatch.

Streamwatch is a fabulous opportunity for schools and community groups to help improve the environment of their local area. Using state-of-the-art field testing kits, groups can carry out a range of scientific tests including phosphorus, dissolved oxygen, faecal coliform and lots more. The results are collated into a powerful database of water quality information.

Water bugs, frogs, algae and habitat are also monitored, providing groups with information on how healthy and productive their waterways are.

With a good understanding of the problems in their local rivers and creeks and the possible causes, Streamwatch groups can then spring into action.

Community awareness campaigns, creek clean-ups, drain stencilling, building artificial wetlands, and educating industry have all been popular and highly successful actions by Streamwatch groups.

Activities
In addition to the water quality testing programs, Streamwatch has some exciting new ways to act for the environment and have fun at the same time -

The Water Bug Survey
It's bug fever as thousands of schools and groups scan their waterways for those elusive bugs that reveal the health of streams. In 1997 over 20,000 people searched high and low for insects, crustaceans, molluscs, and worms. The survey is fun, and the results form an important snapshot of stream health across NSW.

Murder Under the Microscope
Murder Under the Microscope is a leading-edge technological eco-game played annually by hundreds of schools across Australia and even overseas. It's go, go, go and school against school as teams of eco-detectives uncover the evidence and probe

the minds of a panel of environmental experts at 'Catchment Headquarters' to be the first to crack the environmental mystery.

Streamwatch 5-8
This is a three-part eco-adventure for school years 5-8. Part A is an eco-game: The Case of the Contaminated Catchment. Part B is a catchment role play. Part C is a water testing activity using the special Streamwatch 5-8 testing kit. Training and support is offered to teachers as part of the program

(http://www.streamwatch.org.au).

EDUCATIONAL GAMES
"Splash"
Desdemona's "Splash" is a game about water quality and the environment. A free demo is available for download from

http://www.epa.gov/OWOW/NPS/kids/splash/webpage2/
or the CD-ROM is available for purchase from the same site.

The game works by identifying actions that will pollute the stormwater in the city, neighbourhood or farm.

POSTERS/BROCHURES
Available from the EPA – relevant posters include
- Don't put plastics in the sea
- Everything we do…urban catchment management
- Know where it all goes

Brochures, leaflets and educational materials are also available (PH 131555)

Promotion of Public Access to the Stormwater System
Promoting public access to the stormwater system may develop a sense of ownership and an increased concern. If the community is involved in the process of stormwater management, they will feel responsible for the identification of potential problems and concerns.

Continue to Hold Workshops Involving all Relevant Stakeholders to Discuss the Process and Issues of the Stormwater System.

The ongoing consultation will ensure that all stakeholders are aware of their responsibilities and an active approach to ongoing stormwater management will be encouraged.

Appendix H: STORMWATER MANAGEMENT DEVICES

A range of structural stormwater management devices are detailed below:

Trash Racks

Trash racks are structures, which are installed in storm drainage channels to intercept floating and submerged objects. They are typically composed of a vertical rack, with bars spaced between 40 and 100 mm apart. Trash racks provide a physical barrier in the storm flow path, which screens out gross pollutants larger than the bar spacing. As material builds up behind the trash rack, finer material can also be trapped.

Trash racks can be either on-line or off-line. On-line trash racks are placed within an existing channel or drainage system, while off-line trash racks consist of a flow diversion mechanism that directs low and medium flows into the rack, with high flows bypassing the structure. Off-line systems are preferred, as there is less chance that the collected material can be lost during high flow conditions. However, in urban environments, the space required to construct an off-line trash rack may not always be available. The design of on-line trash racks may need to consider the ability of the structure to retain the gross pollutants during higher flow events. This could be achieved by placing a lip at the top of the rack, or by incorporating a litter net above the structure.

Figure 1.1 shows a typical trash rack downstream of stormwater outlet pipes.

Figure 1.1 - Trash Rack

Advantages

- Can be retro-fitted into existing drainage systems
- Collects litter at a single location, rather than over a large area
- Simple to construct

- Can also trap coarser sediments when the trash rack becomes partially blocked

Limitations

- Can cause upstream flooding
- Previously caught material may be remobilised if overtopping occurs
- Difficult to maintain, and required manual maintenance (ie high costs)
- Appearance of the trash rack and accumulated litter can be obtrusive
- Potential odours and health risks to workers during cleaning
- Not suitable for tidal applications

CRCCH (Allison et al, 1998) indicates that the gross pollutant removal efficiency of trash racks is low to moderate. NSW EPA (1997) expands this into a moderate to high trapping efficiency for litter, and a low trapping efficiency for oxygen demanding material (ie organic). If properly designed, trash racks require cleaning approximately monthly.

Gross Pollutant Traps (GPTs)

A Gross Pollutant Trap (GPT) is a sediment trap with a trash rack located at the downstream end. Sediment is removed from the stormwater via settling action, while litter and organics are intercepted by the downstream rack. GPTs generally consist of a large concrete lined wet basin upstream of a weir, with the trash rack located above the weir.

GPTs permit coarse sediments (ie sands and gravels) to settle to the bottom of the structure by decreasing the stormwater flow velocity. This is achieved by increasing the flow conveyance area through the wet basin (ie widening and deepening of the waterway).

GPTs can be classified as either major GPTs or minor GPTs. Major GPTs are open structures and are intended to be located in large floodways, capable of treating medium to large flows. Minor GPTs are closed structures, and are intended to treat stormwater runoff from local catchments only. Minor GPTs can be incorporated into enlarged gully pits, with fixed litter screens and sediment trapping achieved by a wet sump (ie invert level of the outlet is higher than the base level of the pit).

Figure 1.2 shows a major GPT, which incorporates both sediment and gross pollutant trapping, while Figure 1.3 outlines the basic principles of an in-line minor GPT.

Figure 1.2 Major Gross Pollutant Trap

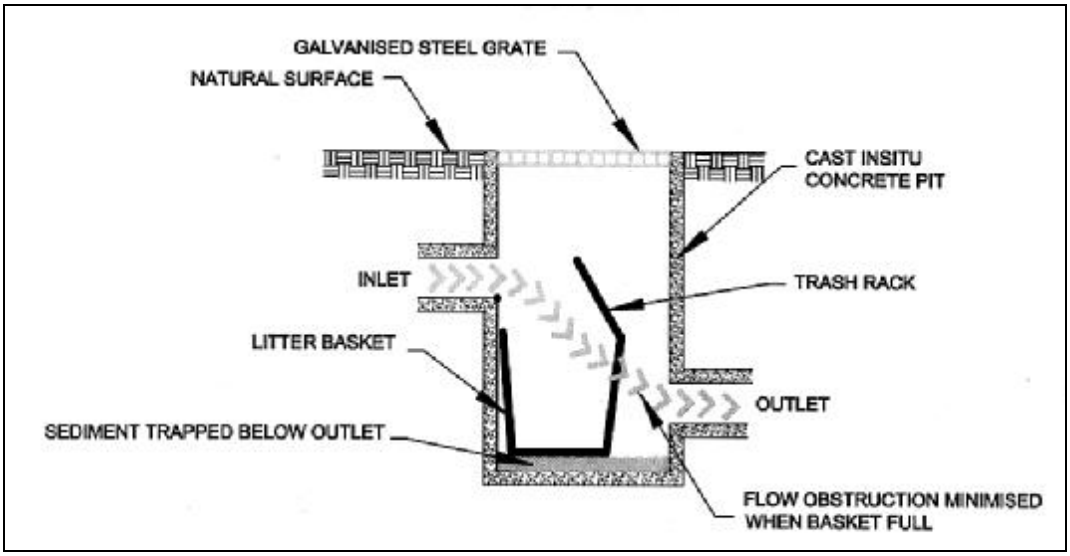


Figure 1.3 Minor Gross Pollutant Trap

Advantages

- Can be used prior to a wetland, pond or other device, thereby preserving the capacity of the downstream structure
- Concentrated litter and sediment at a single location for ready removal
- Can be retro-fitted into existing stormwater systems
- Small traps can be located underground, minimising visual impacts

- Generally offers a larger rack length than conventional trash racks, thereby improving the gross pollutant trapping rate

Limitations

- Trash rack can suffer blockages, and aggravate upstream flooding
- High construction costs
- Difficult and expensive to clean
- Limited removal of fine sediment or soluble pollutants
- Appearance of trap and accumulated litter can be obtrusive
- Previously caught material may be remobilised if overtopped
- May be a barrier to fauna migration

CRCCH (Allison et al, 1998) indicates that the gross pollutant removal efficiency of GPTs is low to moderate. NSW EPA (1997) expands this into a moderate to high trapping efficiency for litter, a low trapping efficiency for oxygen demanding material (ie organics), and a moderate to high trapping efficiency for sediment. If properly designed, GPTs only require cleaning approximately 1 - 6 monthly.

CDS Traps and Similar Proprietary Devices

The Continuous Deflective Separation (CDS) Trap, developed by CDS Technologies, consists of a circular separator screen contained within a hydraulically balanced chamber. Flows entering the unit are deflected within this screen to form a vortex. Solids are kept in motion and slowly make their way to the centre of the vortex, while water passes through the outer screen. Gross pollutants cannot penetrate the screen and therefore are retained within the central chamber. Blocking of the screen is prevented by the high lateral velocities.

Advantages

- Very high gross pollutant removal rate
- Low head requirements
- Can be retro-fitted into existing stormwater system
- Concentrated collection of sediment and litter
- Minimal visual impact, as typically installed underground
- Minimal quarterly maintenance
- Non-blocking due to continual circulation of water

Limitations

- Expensive to install
- Subject to soil conditions
- Potentially large structure requiring substantial area and depth

- Potential odours resulting from trapped pollutants

Figure 1.4 shows the basic configuration of a CDS Trap.

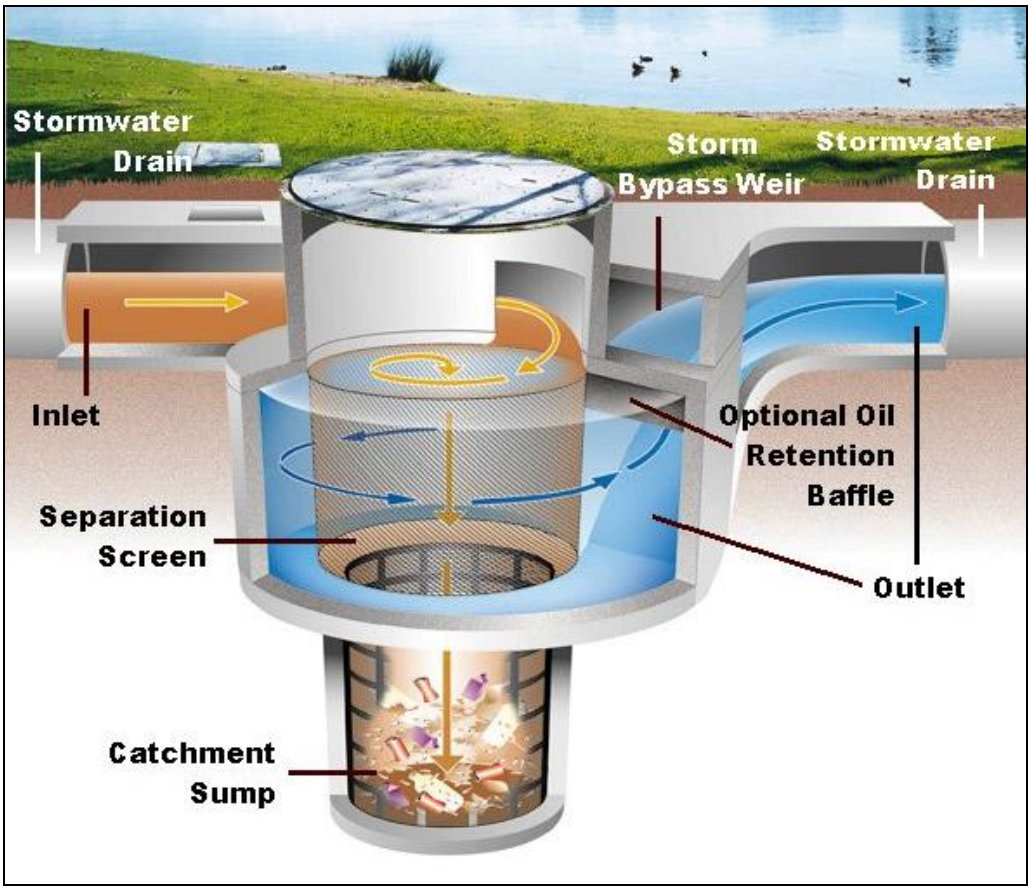


Figure 1.4 CDS Units

By all reports, the trapping efficiency of CDS Traps for gross pollutants is very high, with up to 98% of all litter and organics being trapped, as well as a large proportion of sediment which has a grain size much smaller than the aperture size of the screen (4.7mm).

Humeceptor

The Humeceptor, developed by CSR Humes, is an in-line circular settling tank which primarily removes oil and sediment from stormwater, although floatables and other gross pollutants may be retained during low to moderate flows. The device consists of an upper and lower chamber. Under normal flow conditions, stormwater is directed into the lower chamber by a drop pipe arrangement. Sediment drops out of suspension within this chamber before the water exits through an outlet riser pipe.

Under high flow conditions, the stormwater overtops the diversion weir and passes through the upper chamber of the device, without disturbing previously trapped sediment and oils. Under these conditions, the lower chamber is bypassed.

Figure 1.5 shows the typical arrangement of a Humeceptor.

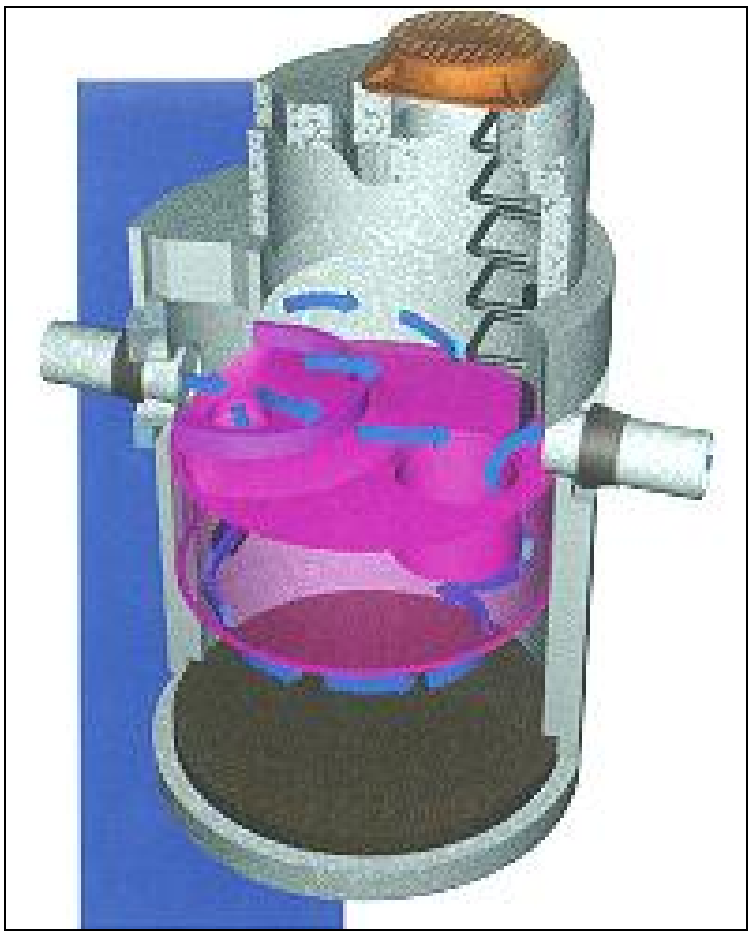


Figure 1.5 Humeceptor

Advantages

- Retains a high proportion of sediments
- Protects collected material from scouring
- Concentrates collection of sediment and oils at one location
- Can collect oils and grease
- Can be retro-fitted into existing stormwater system
- Visually unobtrusive as it is installed underground

Limitations

- Can become blocked by debris and litter
- Ability to trap litter and organics is limited
- High construction cost
- Suitable for small design flows only

The Humeceptor has a relatively good trapping efficiency for sediments, however, the design flows are relatively small, meaning that application is generally limited to small catchment areas only.

Rocla Cleansall

The Cleansall unit, by Rocla, is similar to the Humeceptor is that it has an upper and lower chamber, and under normal flow conditions, stormwater is diverted from the upper chamber into the lower chamber via a series of down pipes. However, in the Cleansall, the down pipes are larger, and are fitted with mesh baskets to capture gross pollutants (ie litter and organics).

A schematic representation of the Rocla Cleansall is shown in Figure 1.6

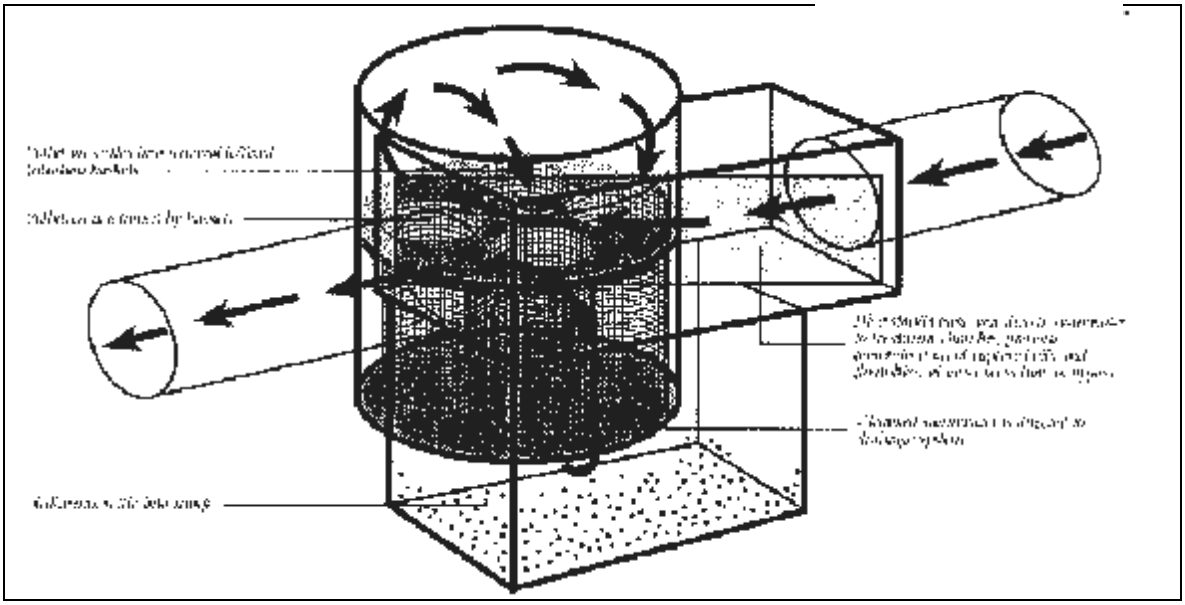


Figure 1.6 Rocla Cleansall

Advantages

- Retains a high proportion of sediments and gross pollutants
- Protects collected material from scouring
- Concentrates collection of gross pollutants, sediment and oils at one location
- Can collect oils and grease
- Can be retro-fitted into existing stormwater system
- Visually unobtrusive as it is installed underground

Limitations

- Can become blocked by debris and litter if not cleaned regularly
- High construction cost

ECOSOL Units

ECOSOL Units are somewhat similar to CDS units in that they can treat larger flows and are suitable for end-of pipe stormwater treatment, however, they operate on a linear system, as opposed to a circular vertex. As stormwater enters an ECOSOL Unit, it is directed into a lower chamber, similar to the Humeceptor. Screens in the lower chamber filter out gross pollutants before the water flows under a oil and grease baffle and then back into the upper chamber and then into the outlet pipe. The sump action of the unit also allows for sediment accumulation, while a high flow bypass ensures the trapped material is not remobilised into the stormwater system.

Figure 1.7 shows the key elements of an ECOSOL Unit.

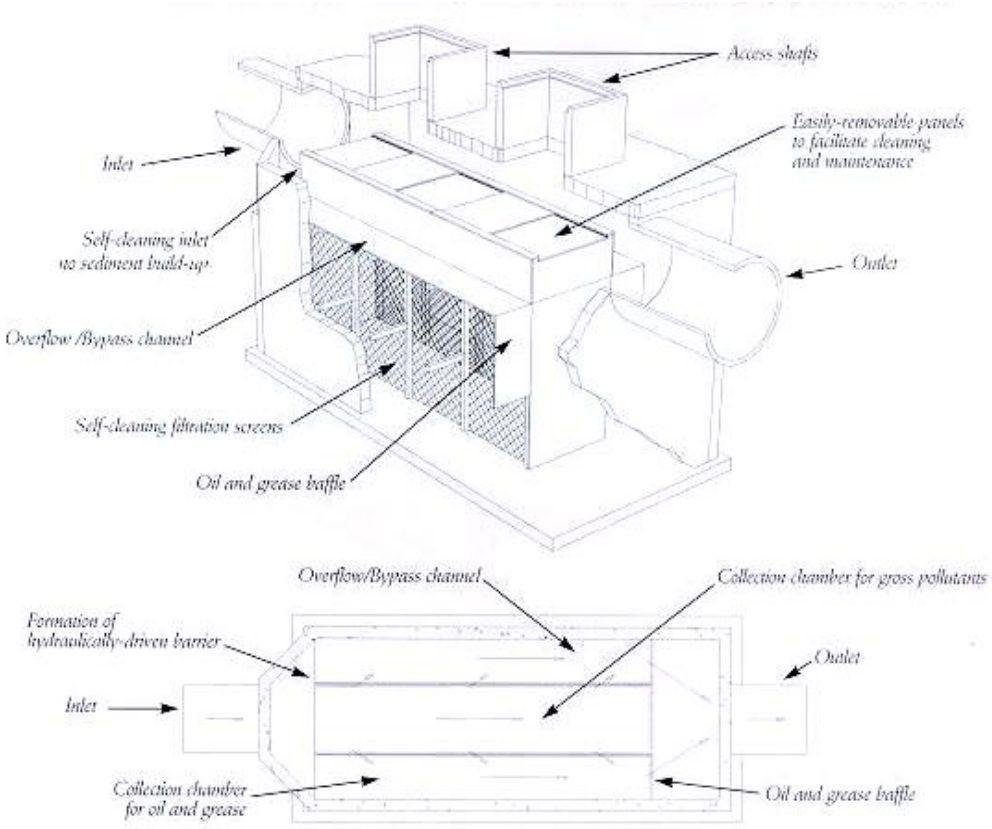


Figure 1.7 ECOSOL Unit

Advantages

- Retains a high proportion of sediments and gross pollutants
- Protects collected material from scouring
- Concentrates collection of gross pollutants, sediment and oils at one location
- Can collect limited oils and grease
- Can be retro-fitted into existing stormwater system
- Visually unobtrusive as it is installed underground

Limitations

- Can become blocked by debris and litter if not cleaned regularly
- High construction cost
- Subject to soil conditions
- Potentially large structure requiring substantial area and depth
- Potential odours resulting from trapped pollutants

Litter Booms and Floating Debris Traps

Litter booms consist of a floating boom and a mesh skirt, which are installed across waterways. The booms trap mostly floatable objects as they collide with it. Litter booms operate best in low velocity conditions. Under high velocities, litter can be forced over and under the structure.

In recent years, conventional litter booms have been modified to improve their material retention capabilities, and to make cleaning easier. These modified booms are referred to as Floating Debris Traps (FDTs), or Bandalong Booms, and are manufactured by Bandalong Engineering. The Bandalong Boom is similar to a conventional boom, however, it includes a collection chamber at the centre of the boom into which all the floatable material is directed. For tidal applications, the chamber includes a flap gate, which prevents the collected material from being remobilised up the waterway during the flood tide.

Figure 1.8 shows the schematical layout of the Bandalong Boom (or FDT), while Figure 1.9 shows an application of the boom in the Yarra River, Melbourne.

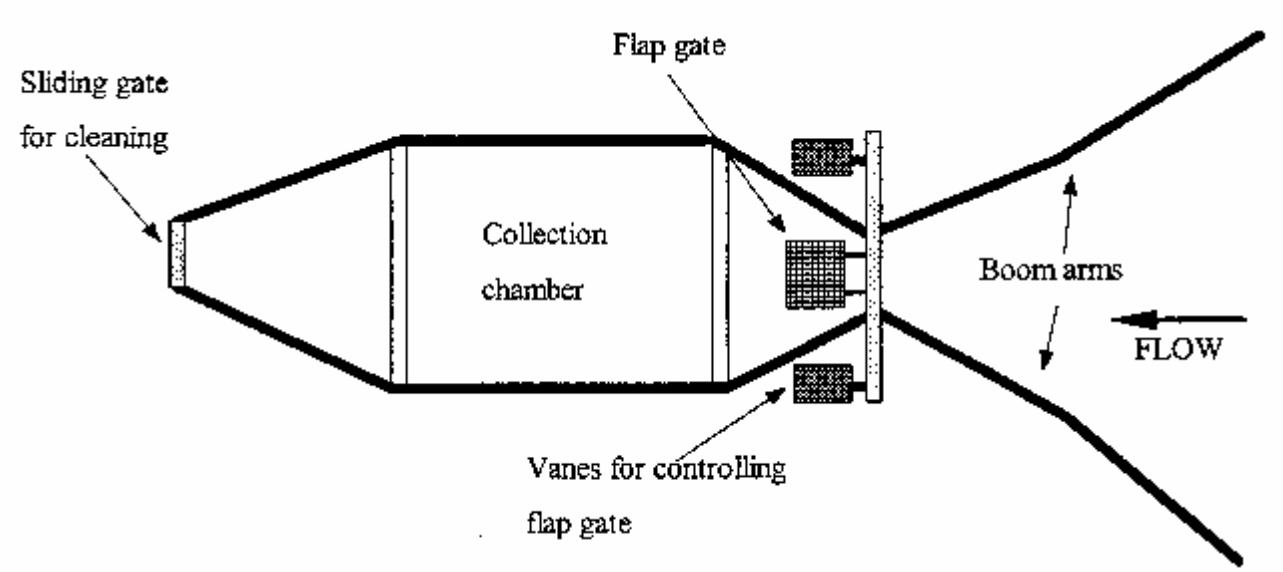


Figure 1.8 Schematical layout of Bandalong Boom

Figure 1.9 Bandalong Boom, Yarra River, Meldourne.

For maintenance purposes, the traps can be pulled to one side of the waterway and cleaned from the shore. Alternatively, the trap can be cleaned by boat.

Advantages

- Enhances aesthetics and recreational potential of downstream waterways
- Improved retention of collected pollutants
- Mobile, and may be retro-fitted to existing waterways
- Collects litter at a single location

- Able to rise and fall with changes in flow or tide
- Relatively cheap to install

Limitations

- Some loss of gross pollutants by wind or high flows
- Can only capture floatable and some suspended load
- Cleaning may be difficult, depending on location
- Boom spans the entire waterway, potentially impeding boating traffic
- Booms may break away from the banks during high flows
- Appearance of the boom and trapped litter may be obtrusive

The trapping efficiency of FDTs is expected to be relatively low, as pollutants can pass both over and under the structure during high flows. However, it is considered that FDTs can significantly reduce the amount of floatable rubbish (eg plastic bottles, plastic bags etc) which can impact on the recreational and environmental values of downstream receiving waters.

Nettech Socks

Nettech litter socks, manufacturer in Coffs Harbour by Net Tech Stormwater Services, is a relatively recent gross pollutant trapping device. It comprises of a netted sock, which is attached to the outlet of a stormwater pipe. The aperture size of the net is in the order of 50mm, and therefore traps most human-derived litter and a large proportion of organic debris, such as leaves and branches. Once the net is full, the hydraulic drag on the trapped material activates a release mechanism. The sock is detached from the pipe flange, but a chord is still connected to the sock, which pulls the sock closed, thereby preventing remobilisation of the trapped material. The sock will remain detached until it is maintained, ie. cleaned and reattached.

Figure 1.10 shows a typical application of a Nettech litter sock.

Figure 1.10 Nettech litter sock.

Advantages

- Cheap and easy to install
- Collects litter at a single location, thus facilitating maintenance
- Does not permit remobilisation of collected material
- Does not affect upstream flood levels
- Can be combined with other control measures to improve efficiency

Limitations

- Can be visually obtrusive
- Is applicable for outlets in open areas only (ie open waterways)
- Does not trap sediments
- Potential odours from trapped material
- Can treat only small areas due to the practical size restriction

The performance of the Nettech litter socks is unknown, however, it is expected that whilst attached, it would remove 100% of gross pollutants which are larger than the aperture size of the net, as well as some finer material when the net is partially

blocked. The overall efficiency of the Nettech socks would be dependent on the amount of time the sock remains detached from the pipe, which is reliant upon the maintenance program for the device.

Modified Kerb Inlet Pits

A range of gross pollutant trapping devices can be installed within kerb inlet pits to remove gross pollutants from the stormwater before entering the stormwater system. Such devices can generally be classified as either catch basins or litter baskets.

A catch basin is a gully pit with a deep base to collect coarse sediment. The invert level of the outlet pipe is positioned well above the base level of the pit, effectively forming a wet sump. Although the cost of constructing individual pits is relatively low, when adopted on a catchment-wide scale the costs can become prohibitive. The high maintenance requirements (ie cleaning every pit in the catchment) can also be very expensive. Consideration must also be given to turbulence within the pit. The higher the turbulence, caused by inflows from the gutter, the more likely previously trapped material would be resuspended and enter the stormwater system. Catch basins do not remove litter or organics from the stormwater.

A litter basket is a small metal or plastic cage within a gully pit. Stormwater entering the pit from the gutter must first flow through this cage before continuing down the stormwater system. The cage filters out gross pollutants (ie litter or organics) down to the aperture size of the cage (5 – 20mm typically). Captured material remains in the basket until manually removed during maintenance.

Figure 1.11 shows the typical arrangement of a gully pit with a litter basket

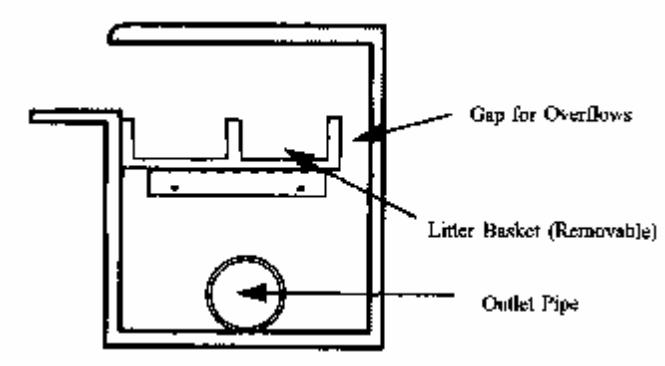


Figure 1.11 Gully Litter Basket

Like catch basins, litter baskets need to be cleaned regularly to be effective. When adopted on a catchment wide scale, the maintenance costs can be prohibitive, despite relatively low installation costs.

Sediment Basin

Sediment basins, or sediment traps, are structures placed within the stormwater system to trap coarse sediment (ie sands and gravels). The can take the form of a 'tank', or a less formal pond. A 'tank' style sediment basin is similar to a GPT, except without the trash rack, while a pond style sediment traps utilise natural waterway features, such as macrophytes, to enhance sedimentation and minimise resuspension.

The size of sediment basins is based on the settling velocity of the design particle, during the design storm event. However, for sediment basins to be reasonable effective, they require an area in the order of about 1% of the total catchment area. It could be expected that sediment basins need to be cleaned periodically, with removal becoming critical when storage volumes exceed 50%.

In general, sediment basins are easy to construct and can reduce significant amounts of coarse sediment from the stormwater. However, they generally require large areas and can be costly to construct. Also, they generally do not remove finer sediments, or litter and organics (unless combined with a trash rack or similar).

The efficiency of a sediment basin depends entirely on the design (ie size compared to design flows). As such, there is potential for high efficiencies to be obtained provided the basin is sized large enough.

On Site Detention

On-Site Detention (OSD) systems incorporate small stormwater holding tanks, which are located between individual lots and the municipal stormwater system. The objective of OSD is to reduce the peak runoff flows generated from the catchment area, which may have increased as a result of increasing the impermeability of the catchment (ie roofs and concrete instead of grasses and trees). Implementation of OSD on a lot by lot basis prevents the need for a more substantial flood detention basin further downstream.

Although OSD is primarily used to control stormwater flows, it can also be adapted to control gross pollutant runoff. For example, a small litter basket could be installed within the OSD tank prohibiting litter and organics from entering the stormwater system, while a catch basin arrangement within the tank could also minimise the sediment load.

OSD would need to be implemented on a catchment-wide basis to have any significant impact on the total gross pollutant loads of a waterway. Such a scenario would have similar maintenance problems as those discussed for catch basins and litter baskets.

Constructed Wetlands

A constructed wetland is a large open shallow water body with extensive emergent macrophytes (large aquatic plants whose parts protrude above the waterline). Epiphytes (algae growing on the surface of aquatic macrophytes) are often associated with macrophytes in wetlands. Three key pollutant retention processes occur in constructed wetlands:

- Enhanced sedimentation
- Fine particle filtration
- Nutrient uptake by sediments, biofilms (eg epiphytes) and macrophytes

Advantages

- Can potentially achieve high sediment and nutrient retention efficiencies;
- Can be incorporated into urban landscapes, providing improved habitat, recreational and visual amenity;
- Can include flood storage to attenuate downstream flows;
- Can potentially be retrofitted to existing retarding basins.

Limitations

- Pre-treatment for removal of coarse sediment and litter is required;
- Requires a large area for construction, and hence can be expensive;
- Reliable inflows are required to ensure some areas remain wet;
- Can take up to 3 years to achieve optimal performance;
- Potential impact on public health and safety;
- May need to resolve groundwater inflow outflow issues.

APPENDIX I - IDENTIFICATION AND RANKING OF VALUES, OBJECTIVES AND ISSUES

RANKING OF VALUES

The values were summarised by the facilitator and ranked by the stakeholders in terms of importance. The challenge was to combine a wide range of values that are held by individuals in a way that allows the achievement of a useful ranking process with outcomes that are acceptable to all.

A two-fold approach was used by the facilitators that encouraged individual participation. The valued ranking scheme was achieved by implementing the following two step approach:

Step 1: Individual Assessment

A ranking table for all the values identified prior to the workshop session was handed to each stakeholder. Each stakeholder was given a total of 100 points to allocate to the list of values and rank them in their personal priority, in a descending order of importance. Some stakeholders might have multiple values that they considered worthy of inclusion but others found that there were a limited number of relevant values that they were interested in.

Step 2: Consensus Gathering

The second stage involved jointly assembling a set of values for the stakeholder group. The facilitators produced from the first step a complete list of all the values raised and the weighting given to them by individuals. Scores were added together to produce an overall weighting score for each value. This was then drawn up in rank order from highest to lowest. This ranking method displays the values in a bar graph rather than just ranking the values as high, medium and low. This allows for a comparison of the priorities put on each value.

Results:

The following section documents the results of a ranking process. Table A shows each stakeholder's score allocation for each of the values. The scores were then added up and Table B was produced showing the total score for each value.

Table A: STAKEHOLDERS INDIVIDUAL SCORE ALLOCATION TO VALUES

Stakeholder "Number"	Total	1	2	3	4	5	6	7	8	9	10	11
Good water quality	285	30	10	25	20	15	40	30	25	25	35	30
Protection of community health and safety	205	20	20	10	30	15	15	15	15	10	35	20
Community involvement and awareness	145	15	10	10	5	15	10	20	10	20	15	15
Protection of habitats	160	15	30	25	5	15	15	5	15	10	15	10
Protection of properties from localised flooding and salinity	95		15	5	20	5	5	20	10	5		10
Aesthetics of the catchment	65		5	5	10	10	5	5	10	10		5

Weed and exotic species control	67		5	15	5	10	5	5	5	10		7
Recreational Value (eg. Ability to swim in the river	78	20	5	5	5	15	5		10	10		3

TABLE B: TOTAL SCORE OF VALUES

Good water quality	285
Protection of community health and safety	205
Community involvement and awareness	145
Protection of habitats	160
Protection of properties from localised flooding and salinity	95
Aesthetics of the catchment	65
Weed and exotic species control	67
Recreational Value	78

OBJECTIVES

The facilitators assembled a list of potential stormwater management objectives, which were drawn from an understanding of the values and issues raised during the one-to-one interviews. These were further discussed with stakeholders and Council at the stakeholder workshop.

At the workshop session, stakeholders were welcome to make changes and additional objectives were added until the stakeholders were satisfied that objectives would address all the stormwater values.

After the workshop, the facilitators scored the stormwater management objectives. The scores of the values (Table 4.3) were used to allocate scores to each objective. This was accomplished by adding up the scores of the values, which have been linked to the objectives (Table 5.6). For simplicity, only key linkages and long term objectives were used in Table 5.6.

RANKING OF ISSUES

Issues Matrix

The ranking was carried out by the facilitators with the aid of an issues matrix. The matrix is based on the potential impact of the issues to affect the values and objectives of the Stormwater Management Plan in terms of consequences and frequency of impact. The following section describes the ranking of stormwater management issues using an issues matrix.

At the workshop, stakeholders and Council representatives selected a number of issues they considered were important in terms of stormwater management in the

study area. Issues identified by stakeholders were also supported by a field inspection of the urban stormwater catchment by Council representatives and external facilitators. A photographic record was also taken of key issues within the catchment, which can be found in Appendix A.

The next step involved assigning a score for each issue indicating its relative impact on stormwater objectives, and the likely frequency of that impact. The scores for the issues were derived by linking each issue to its related objectives. (Refer to Table 6.2). Scores of the objectives (previously obtained from a value-objective linkage table) were added up to determine the final score for each issue. See the following table for the issues score, hence their impact. The frequency was determined by examining the cause, location of each issue and by catchment inspections.

Issues which were considered to have an **insignificant** impact on objectives were allocated a **low score** and issues which were assessed as having a **high impact** on objectives were given the **highest impact score**. Issues which had a very low occurrence within the catchment (or were unlikely to occur) were given a **low frequency score**, while issues that were very likely to occur within the catchment were given a **high frequency score** (see Table C).

TABLE C: ISSUES RANKING SCHEME - Assigning an Impact and Frequency		
IMPACT ON VALUES AND OBJECTIVES (Vertical axis)		**SCORE ALLOCATION OF ISSUES**
1	Insignificant impact on values and objectives.	0-272
2	Low impact on majority of values and objectives	273-544
3	Moderate impact on most values and objectives	545-816
4	Significant impact on most values and objectives.	817-1088
5	High impact on all values and objectives (for significant time periods)	1089-1360
FREQUENCY OF IMPACT (Horizontal axis)		
1	Very rare (few reports)	
2	Occurs occasionally (event occurs once a year or less)	
3	Moderate frequency (occurs at least every 6 months or more)	
4	Occurs often (occurs in heavy rainfall or occurs every few months)	
5	High to very high occurrence (eg almost every time it rains or is ongoing)	

Table D: ISSUES SCORES (IMPACT)

Issue	Score	Impact Score	Frequency Score
Insufficient community awareness	1,360	5	4
Erosion	1,340	5	5
Planning issues	1,335	5	3
Infrastructure/maintenance issues	1,120	5	3
Decreased water quality	930	4	3
Localised flooding from stormwater	520	2	3
Impact on Community health & safety	195	1	2
Impact on aesthetics	135	1	4
Impact on aquatic & terrestrial habitats	135	1	3

The purpose of the matrix is to identify critical, intermediate and less critical issues for the Stormwater Management Plan. After each issue was scored, the issues were then included in the issues matrix for ranking. With reference to the issues matrix, the impact score increases as it goes up the vertical axis (from 1 to 5) which was based on the scores obtained from the link of issues to objectives. The frequency score increases as it goes from left to right on the horizontal axis (1 to 5). Therefore, issues that are scored as having a low impact and are assessed as having a low frequency would be found in the bottom left hand corner of the matrix. As issues increase in their relative impact and likely occurrence, they would move across the matrix to the top right hand corner, incurring a high ranking score. The highest score possible is 5x5, with the lowest score possible being 1x1.

The ranking scheme aids in the development of management options for the highest priority issues in the catchment. Higher priority issues, particularly those ranked 1, should be given a higher priority than issues ranked 2 or 3 when management options were being developed.

The issues matrix can be seen in Figure 6.4 in the document. The issues matrix shows which issues are of the most significance in Mudgee.