NORTHROP
CONSULTING ENGINEERS

Grafton Bond Store
60 Hickson Road
Sydney NSW 2000

PO Box H171
Australia Square NSW 1215

Telephone (02) 9241 4188
Facsimile (02) 9241 4324
Email sydney@northrop.com.au

# WAGGA WAGGA PLANNING STUDY

# MOORONG STUDY AREA

# ENVIRONMENTAL STUDY - STORMWATER

**JOB NUMBER: 07519**

**REVISION: 5**

**DATE: September 2008**

Prepared by:

S. Fryer

Northrop Engineers

Prepared For:

Wagga Wagga City Council

Reviewed by:

M. Richards

Northrop Engineers

TABLE OF CONTENTS

## 1.0 Moorong Study Area

The Moorong Study Area is a triangular-shaped parcel of land located at the intersection of Moorong Street and Edward Street (west of the Wagga Wagga Town Centre). The Flood Levy forms the north / north-western boundary to the site. The site area is approximately 9.5ha.

The subject site is predominantly a low-lying, flat basin. This is a result of elevated portions of the site adjacent to Moorong Street, Edward Street and the adjoining section of flood levy.

The majority of the land is currently utilised for rural purposes such as grazing. Existing pockets of natural vegetation are present on the site. The majority of the natural vegetation has been cleared and replaced with low grass cover that suits rural applications. Figure 1.0 show the study area and key features.

Photo 1.0: Moorong Area – view south from levy bank

## 2.0 Hydrology

The Moorong Study Area is the lowest point of the Glenfield Carrier Catchment. The Glenfield Carrier Catchment is the largest stormwater catchment within the Wagga Wagga urban area (i.e. catchment area = 1830ha) – refer to Figure 1.0. Runoff from approximately 75% of the Wagga Wagga urban area drains to the Glenfield Carrier / Study Area site.

The majority of the Glenfield Carrier catchment has been developed, except for a portion forming the (separate) Lloyd Study Area – at the top of the catchment. The total catchment includes old and new areas of Wagga Wagga. The newer portions (developed within the last 25 years) are predominant and are located directly south of the Study Area.

The design of stormwater drainage facilities servicing newer areas typically consists of a traditional pit and pipe system, with provision for overland flow paths and stormwater detention facilities. The desired outcome is that stormwater runoff is retarded so that flooding of the downstream portions of the Glenfield catchment is prevented. Our site inspections, and anecdotal information provided by Council, indicate the existing on-site stormwater detention system within the newer areas has limited ability to reduce peak flows.

Older areas of the catchment, generally to the east of the study area, are not serviced by stormwater detention facilities, and therefore stormwater flows are uncontrolled. As a result, large flows can arrive quickly at the downstream portions of the site during rainfall events.

The Moorong Study Area is the last downstream node of the catchment. Therefore it receives all flow from the Glenfield Carrier Catchment prior to being discharged to the Murrumbidgee River. Figure 2.0 shows the extent of the Glenfield Carrier Catchment.

## 2.1 Existing Catchment Flows

Existing flows from the Glenfield Carrier Catchment have been estimated – refer to Table 2.1. These values represent the maximum peak discharge. The calculations have not considered the potential for stormwater storage areas within the catchment, or physical restrictions controlling / limiting catchment flow.

Table 2.1 Existing Catchment Flows

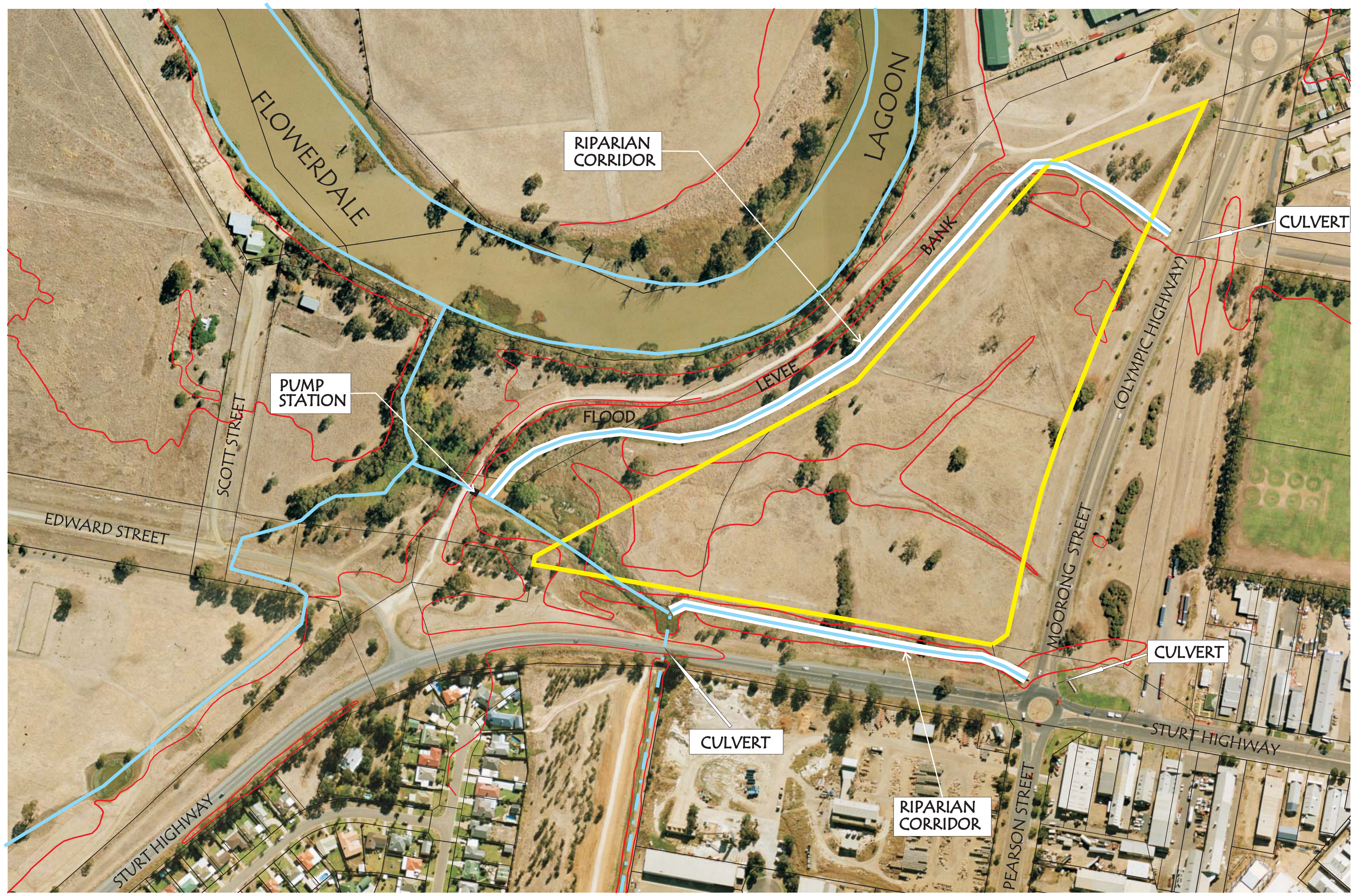
| | | Peak Flow ($m^3/s$) | | | |
|---|---|---|---|---|---|
| **Moorong Catchment** | **Catchment Area (Ha)** | **5 Year ARI ($m^3/s$)** | **20 Year ARI ($m^3/s$)** | **50 Year ARI ($m^3/s$)** | **100 Year ARI ($m^3/s$)** |
| 1 | 1830 (14) | 13.62 (0.10) | 23.90 (0.18) | 34.66 (0.27) | 43.3 (0.33) |

Note: The number in brackets represents the portion of the catchment that falls within the study area and peak flow generated from this as a sub catchment of the total catchment area.

# MOORONG STREET STUDY AREA

FIGURE 1.0

APPROX. SITE AREA=9.5ha




## LEGEND

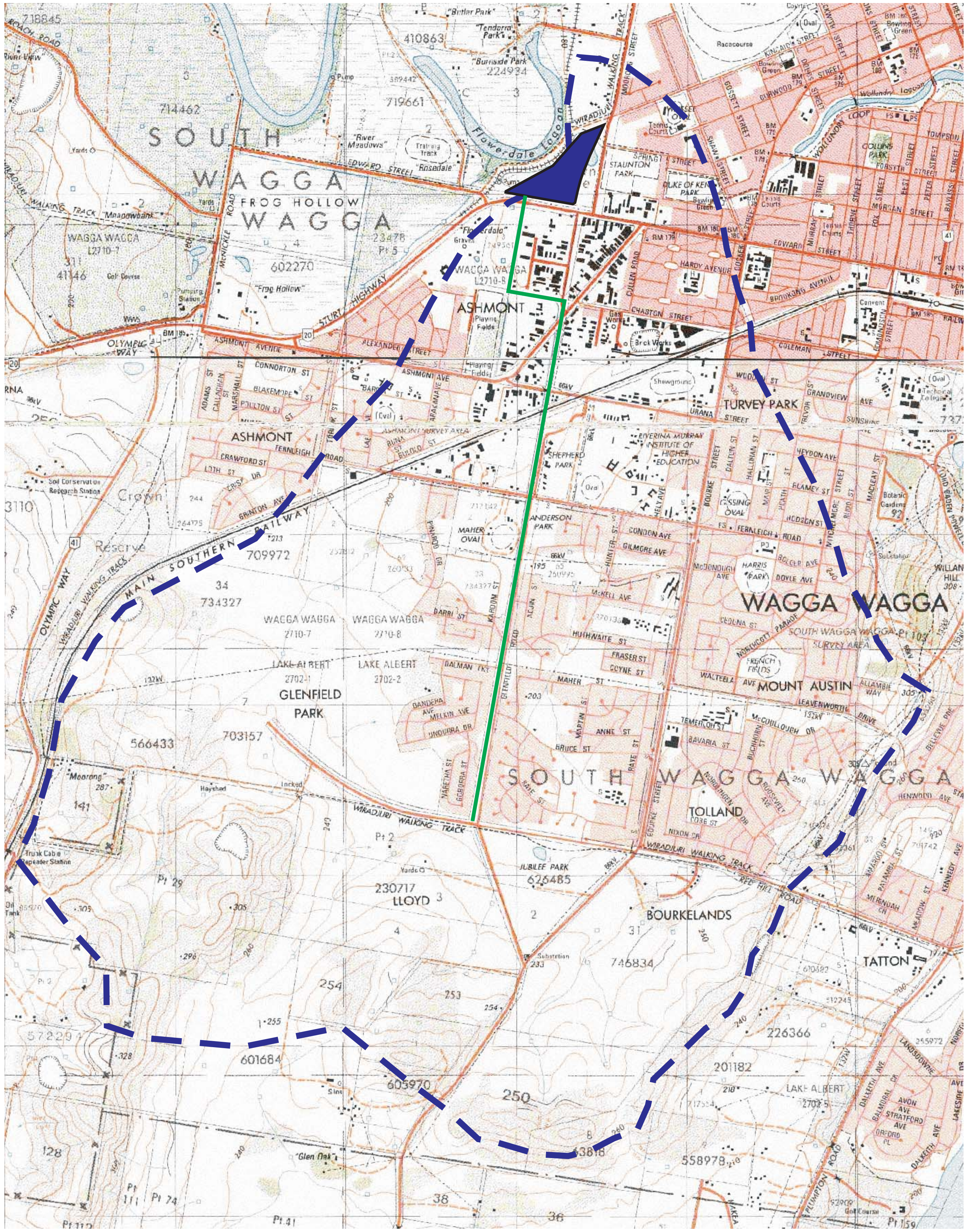
- STUDY AREA BOUNDARY
- CONTOURS
- DIRECTION OF OVERLAND FLOW
- WATERCOURSE
- CATCHMENT BOUNDARY
- DRAINAGE CHANNEL

N

0 40 80 120 160 200

Scale 1:4000

NORTHROP




# UPSTREAM CATCHMENT

FIGURE 2.0

CATCHMENT BOUNDARY

GLENFIELD CARRIER

MOORONG STUDY AREA

N

0 300 600 900 1200 1500

Scale 1:30000

NORTHROP

## 3.0 Stormwater Drainage

Stormwater runoff from the entire Glenfield Carrier catchment enters the site at the following locations:

- Culvert under Moorong Street near Spring St – discharging flows from the older portions of the catchment.
- Culvert under Edward Street - Glenfield Carrier discharges flows from the newer portion of the catchment.

We anticipate flows to the Moorong site would be limited by the hydraulic capacity of both culverts. However, once the capacity of the culverts is reached, ponding would occur to a level where runoff would then overtop the road and drain to the site.

Prior to any of these specific site controls being implemented a detailed analysis required of the Glenfield Carrier Catchment to determine appropriate Flood Planning Levels.

Photo 3.1: Glenfield Carrier – culvert under Sturt Hwy

The natural paths for drainage from the Glenfield Carrier Catchment to the Murrumbidgee River are obstructed by the flood levy adjoining the Moorong site. Therefore the following specific drainage provisions are associated with the site:

- A culvert has been installed adjacent to the Moorong site to enable the discharge of runoff to the Murrumbidgee River.

- Backwater from the Murrumbidgee River floodplain is prevented from entering the culvert by the activation of flood gates.

- A pump system has been provided to drain Glenfield Carrier Catchment / Moorong site when the flood gates are closed.

It is understood that once the drainage system becomes reliant on pumps, the discharge capacity from the catchment is significantly reduced. In this scenario it is highly likely that ponding of stormwater will occur at the Moorong site – causing flooding. Existing site constraints and features are shown in Figure 2.0.

## 4.0 Flooding of the Moorong Study Area

Flooding of the Moorong Study Area can occur as a result of one (1) of two (2) possible scenarios:

a. Flood waters from the Murrumbidgee River overtop the levy, or

b. The capacity of the flood levy culvert and pump system is exceeded.

Photo 4.1: Top of Levy and Pumps

### a. Murrumbidgee Flood Waters Overtop the Levy

The flood levy has been constructed to protect Wagga Wagga from flooding of the Murrumbidgee River up to a predetermined flood height (RL 180.5 - AHD). The levy was constructed with the aim to protect Wagga from the 1% AEP flood event (1in 100 year). It is understood that recent preliminary investigations have revealed the level is only rated to protect against inundation from a 65 year ARI flood event (not the design 100 year ARI event).

**b. Capacity of the Flood Levy Culvert and Pump System being Exceeded**

All stormwater runoff from the Glenfield Carrier Catchment is discharged through the levy culvert and pump system. If the capacity of this system is exceeded stormwater will back-up and store in the natural basin that forms the Moorong site. It is estimated floodwaters from this scenario could rise to a depth of 2.5 to 3.0 metres.

The simultaneous events of the Murrumbidgee River in flood and critical 100 year storm flows from the Glenfield Carrier Catchment would create the worst case scenario for flooding on the site. This is due to the floodgates being closed and drainage of the Glenfield Catchment being solely reliant on the Moorong site pump system. While it is unlikely, the nature of this event would need to be considered in line with engineering best practice and the provisions of the NSW Floodplain Management Manual.

The flood storage provided by topography of the site provides benefit to the greater catchment (upstream). This relates to maintaining relatively low flood / backflow conditions on-site, thereby limiting flooding upstream.

Ultimately, it is considered the Moorong site provides stormwater detention for the Glenfield Carrier Catchment. If development was to proceed on the site, flooding implications due to loss of flood storage should be considered. Furthermore detailed analysis would be required to determine an appropriate Flood Planning Level for the site and surrounding areas (particularly adjacent the downstream portion of Glenfield Carrier and culvert crossing Moorong Street).

## 5.0 Existing Site Runoff Quality

Existing site runoff quality has been considered based on the current usage of the study area. The following table identifies potential sources of contaminants for the site under pre-developed conditions. The risk of contamination to watercourses due to current usage is considered to be minor.

Table 5.1 Existing Potential Contaminant Sources

| | Contaminant | | | | | | |
|---|---|---|---|---|---|---|---|
| **Catchment** | **Solids** | **Nutrients** | **Micro-Organisms** | **Dissolved Oxygen Demands** | **Metals** | **Oils** | **Synthetic Organics** |
| All Catchments | Soil Erosion<br>Cleared Land<br>Animal Waste | Soil Erosion<br>Cleared Land<br>Animal Waste<br>Fertilisers | Cleared Land<br>Animal Waste | Soil Erosion<br>Animal Waste | Soil Erosion<br>Fertilisers<br>Pesticides | Pesticides | Pesticides |

Northrop has undertaken preliminary analysis to estimate annual pollutant loads for the Moorong Study Area. "MUSIC" water quality modelling software was used. Results of the initial modelling are summarised below.

Table 5.2 Estimated Annual Pollutant Loads

| Catchment | Annual Flow (ML/year | Total Suspended Solids (kg/year) | Total Phosphorus (kg/year) | Total Nitrogen (kg/year) | Gross Pollutants |
|---|---|---|---|---|---|
| Moorong Site | 5.5 | 225 | 0.95 | 8.1 | 0 |

# 6.0 Built Environment

Northrop has prepared the following Planning and Development Guidelines for Stormwater Drainage and Flooding. The Guidelines have been based on the Moorong Study Area being rezoned for commercial or industrial purposes.

## 6.1 Stormwater Planning Matrix

The Planning Matrix below identifies stormwater planning and design issues that must be resolved during development planning of the site. Appendix A provides a detailed description of the notation and terminology referred in the Planning Matrix.

Table 6.1. Stormwater Planning Matrix

| Study Area | Primary Land Use | No. Of "Blue Lines" | No. of C'ments | Upstream C'ment | Site Discharge Controls | Salinity Controls | Flood Liable Land | Stormwater Quantity | Stormwater Quality | Rainwater Re-Use |
|---|---|---|---|---|---|---|---|---|---|---|
| Moorong | Industrial | 1 | 1 | Yes | Levy Culvert, Floodplain Water Levels, Pumps | No | FL2 | Q2 | QB, QD | RA |

## 6.2 Stormwater Quantity Management

As the site is flood liable and located at the lower end of the catchment it is preferable to discharge all stormwater runoff generated from the site as early in the storm event a possible. In such a situation it is preferable not to detain stormwater runoff.

It is understood that the site would be developed for commercial or industrial purposes. Commercial/ industrial sites have high impervious area ratios which resulting in greater runoff volumes. Future stormwater quantity management policy for the site shall incorporate a provision to forego on-site detention if it can be demonstrated no adverse impacts are caused due to development.

Stormwater quantity management strategies may include rainwater re-use, minimisation of impervious areas or incorporation of permeable pavements. Rectification/augmentation of existing drainage infrastructure may also minimise the impacts of development.

## 6.3 Stormwater Quality Management

Industrial development has potential to significantly increase pollutant loads in stormwater runoff. This is particularly dependent on the type of industry. On this basis, stormwater quality management should be undertaken on an individual Lot basis to target specific contaminants being generated from industrial sites.

In general, the concepts, principles and controls specified in Appendix C and D must be considered when implementing a water quality management strategy for the site.

## 6.4 Rainwater Re-use

Rainwater harvesting and re-use schemes are encouraged for all development.

The provision of rainwater re-use systems has significant positive impacts in reducing the volume and quality of stormwater runoff generated from the developed site.

The provision of no rainwater reuse system will only be considered where significant negative impacts are demonstrated (e.g. ownership / operational issues, site salinity, interruption to the water cycle, public health issues, etc.).

Rainwater re-use promotes water conservation and underpins any strategy incorporating Water Sensitive Urban Design. In this regard, rainwater re-use systems have the potential to:

- Decrease the quantity and rate of stormwater runoff from a catchment;
- Decrease demand on the potable water supply; and
- Decrease the pollutant load of stormwater discharged from a catchment.

Treatment of harvested stormwater needs to be considered to suit its intended purpose. This will involve researching the level of treatment and on-going monitoring and maintenance necessary to minimise risks of contamination to end-users and operators of the subject facility.

# 7.0 Riparian Zones

Generally, the NSW Department of Water identifies “Blue Line” watercourses (as shown on 1:25,000 topographic maps) as major drainage corridors. These corridors are typically associated with requirements for riparian habitat protection. The minimum riparian zone for the “blue line” water courses (as shown in Figure 1.0) has been calculated at 20m. As such development can not proceed within this corridor.

However, it should be noted the final width and extent of work allowed within the drainage corridor would be subject to the habitat protection objectives - prescribed by the NSW Department of Water. The extent of the riparian zone is shown on Figure 1.0.

# 8.0 Costing

Future stormwater management facility works for the Moorong site is dependant on an upstream catchment and flooding analysis is beyond the scope of this study. Future works may include:

- Detailed flood modelling of the site to determine an appropriate flood planning level (FPL).
- Augmentation of the pump system located adjacent to the site
- Provision of additional detention facilities within the Glenfield Carrier Catchment upstream of the Moorong site.

Photo 7.1: Typical “Blue Line” Watercourse located on site

## 9.0 Stormwater Management Recommendations

Development activity is likely to increase runoff volumes and pollutant loads. Post-development flows need to be managed to minimise impacts downstream, while maintaining existing (environmental) flows to support habitats.

The following measures should be considered as part of an overall stormwater management system. The system shall ensure existing site flows are maintained, while minimising the effects of excessive runoff rates and volumes.

The following strategies should be employed as part of an overall stormwater management and water cycle plan.

- A Lot-based stormwater impact assessment should be provided at the Development Application Phase for each Lot. The impact assessment will need to demonstrate no adverse effects will occur elsewhere in the catchment as a result of the intended development. Stormwater management strategies such as rainwater re-use schemes; minimisation of impervious areas, permeable paving or on-site detention may be adopted to achieve this outcome.

- *Rainwater Re-use Schemes* provide an alternative water source. The harvested water can easily be used for non-potable purposes (although, requirements for monitoring and treating the condition of harvested rainwater need to be considered).

- *Reducing Impervious Areas* assists to control the volume and rate of stormwater runoff. Measures to assist with optimising pervious / impervious ratios include limiting paved surfaces, incorporating of permeable paving and grass-lined corridors for drainage to complement landscaping. This strategy should be incorporated with a vegetation management plan to use native plant species.

- *Water Sensitive Urban Design (WSUD) Principles* that control the quality of stormwater discharged from the Study Area are to be incorporated (as outlined in Appendix D). Specific measures include pollution control devices, wetlands systems, bio-retention treatment facilities and maintaining site discharge rates that support environmental habitat downstream.

- Water quality targets shall be determined by the procedure indentified in Appendix C. As a minimum pollutant levels for the post-development scenario shall not exceed pre-development levels.

- The site is susceptible to local and regional flooding. On this basis, the site is considered unsuitable for residential development.

## 10.0 Conclusions

(a) Potential for flooding of the Moorong site is caused either by:

- Stormwater runoff from the Glenfield Carrier Catchment exceeding the capacity of the culvert and pumps at the flood levy. Furthermore the capacity of the discharge structures directly relate to water levels within the floodplain.
- Flood waters from the Murrumbidgee Flood Plain over topping the levy.

(b) The Moorong study area provides flood storage which ultimately minimises expected flood levels elsewhere in the downstream portion of the Glenfield Carrier Catchment.

(c) Reliance on the Moorong Study Area as a flood storage site may be reduced by improvements to the flood storage capacity or stormwater detention provisions upstream of the Moorong site.

(d) Increased peak runoff flows from the Moorong site (once developed) would have little or no impact on the Glenfield Carrier Catchment. This is due to its close proximity to the discharge point / Murrumbidgee River.

(e) Acceptable water quality for stormwater runoff from future development could be achieved. It is recommended water quality treatment systems are design on a Lot-by-Lot basis to target specific pollutants associated by the particular industry.

(f) Loss of flood storage and the existing catchment discharge conditions is the key impact affecting the Glenfield Carrier Catchment as a result of potential development of the Moorong site. It is envisaged any future development of the site would necessitate some filling of the Moorong study area. Filling operations will reduce the available flood storage, and provision for back-up at times when the drainage culverts / pumps are operating.

(g) Detailed stormwater modelling of the entire Glenfield Carrier Catchment is recommended to determine the impact of the Moorong site development. This Study could extend to (i) outline suitable upstream measures for controlling runoff to the site, and (ii) ascertain flood planning levels for the subject site and surrounding areas.

(h) Rezoning or development of this should not proceed until the modelling in point (g) has been completed.

# APPENDIX A – STORMWATER PLANNING MATRIX

## A1 Description of Matrix

The purpose of the matrix is to provide a systematic approach in identifying opportunities and constraints to stormwater management for the Study Areas associated with the 2007 Wagga Wagga Planning Study. This will then enable stormwater management measures to be implemented to optimise development, respond to specific site conditions and consider the proposed land-use.

| Study Area | Primary Land Use | No. Of "Blue Lines" | No. of C'ments | Upstream C'ment | Site Discharge Controls | Salinity Controls | Flood Liable Land | Stormwater Quantity | Stormwater Quality | Rainwater Re-Use |
|---|---|---|---|---|---|---|---|---|---|---|
| *Refer to Section A2* | *Refer to Section A3* | *Refer to Section A4* | *Refer to Section A5* | *Refer to Section A6* | *Refer to Section A7* | *Refer to Section A8* | *Refer to Section A9* | *Refer to Section A10* | *Refer to Section A11* | *Refer to Section A12* |

The Stormwater Planning Matrix identifies key issues and objectives to facilitate the planning and design of major drainage system components. The Matrix provides the framework for designers to determine solutions that will address the likely impact of proposed development. The process also seeks to inform the LES process by identifying appropriate stormwater drainage measures that are environmentally sensitive and minimise this impact.

The Goal of the Matrix is to identify the Stormwater Planning Controls associated with each of the respective Study Areas, while still encouraging innovation and best practice solutions.

Appendix A provides detailed descriptions for the criteria used to identify opportunities and constraints, as well as a method for constructing the stormwater planning framework for each Study Area.

## A2 Primary Land Use

Land-use correlates to the quantity and quality of stormwater runoff from a site. The amount of impervious area characterising the land-use is the main influence of this. As impervious area increases so does the volume of stormwater runoff and the potential for pollutant runoff. Conversely, more pervious site areas encourage ground infiltration and filter pollutants in runoff.

Typically, for urban areas, industrial lands have the highest impervious area ratio, while low density residential lands have the least. For calculation of peak runoff values for the sites nominated in the Wagga Wagga Planning Study the following post-development fraction impervious values were adopted.

| Land Use | Fraction Impervious |
|---|---|
| Low Density Residential | 65% |
| Industrial | 90% |
| Mixed Use | 85% |

With reference to the Planning Matrix:

- The "Primary Land-use" column defines the predominant type of development expected in the study area (Post-Development Case).
- *Residential development* is defined low density housing (typical lot size between 750m$^2$ and 1000m$^2$ dispersed with small pockets of commercial and special uses lands).
- *Residential development* also incorporates commercial area, roadways, open space or recreational areas normally found within this type of development.
- For portions of the study areas where *rural residential development* is proposed a lower fraction impervious value of 40% may be adopted.
- *Industrial Development* refers to employment lands used for shop fronts, light manufacturing, warehousing / stockpiling, or transport depots. Heavy manufacturing is not expected on these sites as water and sewer infrastructure could not accommodate demands. Types of operations within industrial lands needs to be considered for specific sites, as it can directly impact the quality of stormwater runoff.
- *Mixed land use* refers to commercial developments such as petrol stations, truck stops or other enterprises requiring a shop front. Types of activities on mixed use lands needs to be considered for specific sites, as this can directly impact the quality of stormwater runoff.

## A3 "Blue Line" Watercourses

The NSW Department of Water identifies "Blue Line" watercourses (as shown on 1:25,000 topographic maps) as significant drainage corridors. These corridors are typically associated with provisions for riparian habitat protection.

Protected watercourses are graded according to their ecological value. Typically, the higher the ecological value, the wider the associated riparian (protection) zone. In this instance, the width of the riparian zone can be dictated by ecological value, rather than width for conveying stormwater runoff.

"Blue line" watercourses can be ephemeral or have permanent flows. The watercourses are natural valleys or depressions within the catchment where surface stormwater runoff is concentrated. Utilising the existing topography of the study area for conveying this runoff provides the most cost-effective outcome for stormwater drainage, habitat protection and maintaining environmental flows to downstream watercourses.

## A4 Number of Catchments in Study Area

The number of catchments refers to quantity of drainage catchments within the study area. Typically each catchment will drain to a "Blue Line" watercourse. Identification of catchments forms the basis for design of catchment-based (communal) stormwater management systems.

## A5 Upstream Catchment

This column identifies whether there are upstream catchments outside of the Study Area that will contribute stormwater runoff to the site (e.g. via surface, watercourses or depressions). Flows from upstream catchments need to be considered when managing stormwater flows in each of the study area.

The capacity of proposed drainage networks within Study Areas will need to accommodate the flows from any upstream catchment – in order to maintain natural flow paths and convey safely through the site.

## A6 Site Discharge Controls

This column identifies existing downstream elements or features that will influence the rate and volume of stormwater being discharged from a Study Area.

## A7 Salinity Controls

Salinity can be managed by good stormwater management practices. Adoption of water sensitive urban design (WSUD) principles will inherently assist in the management of salinity. Some stormwater management measures such as ground water recharge or infiltration are not suitable in areas susceptible to salinity. Flagging salinity early in the planning process allows sympathetic stormwater management measures to be economically adopted.

Any stormwater infiltration mechanism that raises groundwater must be avoided in order to manage salinity. In some instances, it may also be preferable to reduce existing levels of infiltration to prevent adverse impacts of salinity.

## A8 Flood Liable Land

Flooding of land within each of the study area can occur as a result of one (1) of two (2) events:

- The Murrumbidgee River overtopping its banks or;
- A localised storm event generating stormwater runoff greater than the capacity of the formal drainage system.

The source of the flooding risk for each study area is identified in this column of the Stormwater Planning Matrix. FL1 denotes flooding is due to the Murrumbidgee River overtopping its banks or levee and inundating the subject site. FL2 denotes indicates the site is susceptible to flooding due to a storm event occurring within the catchment. Generally flood risk denoted as FL2 is due to the existing downstream drainage network being under capacity.

This assessment has not considered the potential effects of the two (2) events occurring simultaneously, due to its unlikelihood.

Appropriate site stormwater management measures are influenced by the potential for site flooding. Furthermore the cause of flooding will influence the type of stormwater management options chosen. For example, if flooding occurs due to a catchment storm event, it is desirable to discharge the peak runoff of low lying lands (or lands subject to flooding) early in a storm event to allow the maximum capacity of the drainage system to be utilised. In such instances stormwater detention would be detrimental to the lower portions of the catchment.

## A9 Stormwater Quantity Management

Urbanisation increases the quantity of stormwater runoff. As a result stormwater quantity management measures need to be adopted so the risk of flooding downstream is not increased. The principles of stormwater quantity management are outlined in Appendix B.

The quantity and rate of runoff discharged from a site can be controlled by the incorporation of stormwater retention and detention facilities into the drainage system. Source controls, such as limiting the amount of impervious area can also be incorporated in order to reduce the peak discharge from a catchment.

The baseline approach to designing for acceptable site stormwater discharge conditions is to control the peak post-development site discharge to be no greater than the pre-development scenario. This is generally to ensure the development does not increase any existing potential for downstream flooding.

Alternatively, any shortcomings in the existing drainage system to convey runoff can influence design - by dictating a maximum discharge from a catchment to suit inadequate downstream capacity. This further increases the reliance on detention and/or retention measures.

The Stormwater Planning Matrix considers design for stormwater quantity management measures according to the following categories:

- Q1 – Pre-development stormwater runoff not to exceed post development for 5 to 100 year ARI storm events for all durations.
- Q2 – Study Area or parts of Study Area located in flood prone land therefore not requiring stormwater detention.
- Q3 – Downstream discharge controls requiring flows to be limited to less than the pre development discharge rates.
- Q4 – Community-based stormwater detention facilities to be provided.
- Q5 – Lot based or on-site stormwater detention (OSD) facilities to be provided.

### A10 Stormwater Quality Management

The impact of urban stormwater on receiving waters is to be understood and managed as part of the development process. The purpose of this column of the Stormwater Planning Matrix is to identify an appropriate stormwater quality target which is dependent on the receiving waterway.

Stormwater runoff from all Study Areas forming the Wagga Wagga Planning Study will eventually flow to the Murrumbidgee River. In this regard stormwater quality targets will be defined by the Murrumbidgee Catchment Authority, in conjunction with engineering best practice.

Invariably, development activity necessitates stormwater treatment measures to be introduced to the drainage network in order to achieve water quality targets. These can be applied through community-based facilities or lot based measures. The Stormwater Planning Matrix considers design for stormwater quality measures according to the following categories:

- QA – Water quality target values which are specified by receiving waters stakeholders
- QB – Site specific values due to location, catchment conditions or site use
- QC – Community-based treatment measures to be provided
- QD – Lot-based treatment measures to be provided

## A11 Rainwater Reuse

Rainwater is defined as stormwater runoff that is collected and treated to a level that allows re-use for a specified purpose. There are numerous ways to utilise rainwater in urban catchments. The potential for rainwater reuse is dependent on the applications within the catchment that can accept rainwater as an alternative means for water supply.

Typically domestic dwellings within urban catchments can easily collect rainwater for non-potable uses - outdoor supply (e.g. irrigation, car washing), toilet flushing and clothes washing machines. Larger scale rainwater reuse facilities can also be incorporated into the drainage network by providing water for open space irrigation and water features.

Each Study Area has the potential to be serviced by a rainwater re-use system. The goal of the Stormwater Planning Matrix is to facilitate full potential for rainwater re-use. Opportunities for rainwater re-use have been identified as follows:

- RA – Lot-based rainwater re-use systems
- RB – Community-based rainwater re-use systems.

Rainwater re-use is a key component of WSUD and therefore every opportunity for incorporation into future development should be explored.

# Appendix B – STORMWATER QUANTITY MANAGEMENT

## B1 Introduction

When urban development takes place in existing rural catchments significant pervious areas are replaced by impervious surfaces. This change leads to an increase in peak catchment flows and an increased volume of surface runoff (downstream of the site).

Increasing impervious area can lead to potential for:

- Flooding of downstream property
- Increasing overland flow to extend outside defined flow paths
- Erosion of natural watercourses

Stormwater quantity management minimises these problems by controlling runoff.

## B2 Objectives

1. Development that does not increase the impact of rainfall events.
2. Development that does not adversely affect the integrity of natural waterways, groundwater and ecosystems.
3. Stormwater quantity management that is in accordance with best practice.
4. Provide stormwater quantity management measures that are functional and effective for the duration of their existence.

## B3 Performance Outcomes for Infrastructure

Best practice stormwater quantity management systems are dependent on three (3) aspects. These derive from (a) the adoption of the major / minor stormwater drainage philosophy, and (b) incorporating detention or attenuation to maintain / improve receiving waterways, habitats and infrastructure.

Major / minor drainage concepts seek to maintain convenience and amenity within the urban landscape during minor (nuisance) storm events and protection for life and property during major (excessive) storms.

Stormwater quantity management need to be considered in conjunction with the major / minor system managing runoff. While, best practice solutions will consider stormwater quality management and Water Sensitive Urban Design (WSUD) principles, also.

As a result, there is a strong interrelationship between the following aspects of design for stormwater quantity management.

### B3.1 Minor Stormwater Drainage System

The minor drainage system comprises the drainage network components that provide convenience and safety to pedestrians and traffic during frequent or minor storm events by controlling catchment flows within prescribed limits. The minor drainage system consists of kerbs, gutters, roadside channels, swales, stormwater pipes and pits designed to contain and convey stormwater runoff for events up t and including minor storms.

The minor drainage system shall be designed to contain and convey the peak flow due to the 5 Year ARI storm.

### B3.2 Major Stormwater Drainage System

The major drainage system incorporates drainage components that ensure residential, commercial, industrial and other habitable areas are protected from inundation during major storm events. The major drainage system consists of roadway reserves, open space areas, floodway channels, and natural watercourses to contain and convey stormwater runoff due to a major or infrequent storm event. Design of the major system is to occur at the Master Plan stage of development, so that a satisfactory level of safety and amenity is provided, whilst preventing devastation caused by major (excessive) storm events.

The major system shall be designed to contain and convey the peak flow due to the 100 Year ARI storm. These systems are to be designed so that velocity/ depth conditions are within prescribed limits.

### B3.3 Stormwater Detention/Attenuation

Stormwater runoff from the post-developed catchment condition is to be retained so that the flow characteristics of receiving waters are improved or as a minimum unchanged from pre-development conditions. This is typically achieved by providing detention / attenuation measures as part of the major drainage system.

In some circumstances, pre-existing flooding conditions downstream or inadequate capacity of receiving infrastructure, watercourses or topography, may require reducing post-development catchment discharge to less than pre-development levels.

## B4 Catchment Discharge Control

Catchment discharge controls are the detention or attenuation measures (such as detention basins, lagoons or rainwater tanks) that control the volume and rate of stormwater discharged from a catchment.

### B4.1 Stormwater Discharge Limits

Discharge control facility design values are defined by the capacity of the receiving waters to accept flows from the catchment. The following limits are to be maintained as the study areas are developed.

| Planning Matrix Code | Description | Catchment Discharge Limit |
|---|---|---|
| Q1 | Pre-development vs. Post development | Post-development catchment discharge not to exceed pre-development catchment discharge for 5 year to 100 year ARI for all durations. |
| Q2 | Flood Liable | Catchment located in Flood Prone areas that does not require provision for stormwater detention facilities. Retention facilities, such as rainwater re-use still need to be provided to meet the objectives of WSUD. |
| Q3 | Downstream Controls | A downstream condition exists where catchment discharge needs to be reduced to less than pre-development levels. The control conditions for each study area are identified in the main body of the report. |

The application of discharge controls should consider environmental flows of the receiving waters. Discharge controls may create higher, more frequent peak flows, during small events. A balance is to be struck between controlling peak flows, yet maintaining an acceptable level for environmental flows that will ensure the health of natural water courses and associated habitats. Guidelines for provision of environmental flow, is described in detail in Appendix C.

## B5 Stormwater Quantity Management Measures

The following measures will need to be considered to minimise the effect of development on downstream stormwater infrastructure:

### B5.1 On-site Stormwater Detention

On-site Stormwater Detention (OSD) allows for the storage and controlled release of stormwater runoff. OSD is designed to ensure stormwater runoff from new development sites does not exceed the allowable discharge rates that are (a) able to be accommodated by the existing (downstream) system, and / or (b) equal to existing site flows.

On-site stormwater detention facilities will be provided at a local catchment level. The facilities are best located:

- Toward the downstream end of sites,
- Outside riparian/conservation corridors and discharge so as not to affect these areas,
- Outside areas susceptible to flooding (up to 100-year ARI), and
- So that connections are not susceptible to backwater from downstream drainage systems.

Care needs to be taken to ensure that stormwater runoff from the development site is not reduced to a level that affects environmental flows supporting downstream aquatic habitats.

### B5.2 Stormwater Retention (Attenuation)

Stormwater retention reduces site runoff discharging to the downstream drainage system. Stormwater is captured to provide an alternative water supply source – thereby conserving mains water consumption. Rainwater can be an alternative source of supply for non-potable and potable water-use purposes – depending on the level of treatment.

Stormwater retention/re-use systems can be applied to individual lots or at a local level. The capacity of individual lots systems can vary from 3,000 to 10,000 litres. The size of local systems is dependent on the demand and use (e.g. irrigation, non-potable water supply to residential lots, etc.).

### B5.3 Optimising Impervious Site Areas

Encouraging pervious site areas reduces the effect of increasing runoff due to paved / hard surfaces. Planning to optimise pervious and impervious spaces can lead to reducing development site runoff. This might consider:

- Permeable paving for public access areas and/or residential driveways/pavements. This will be subject to installing filtration media and subsurface drainage systems – where clay / impermeable soils exist on-site.
- Grassed swales for collecting and conveying stormwater runoff. Again, this will be subject to installing trickle drain / filtration media and sub-surface drainage systems to avoid saturating ground immediately under grass / vegetation.
- Limiting paved surfaces.

### B5.4 Off-Site Works

Scope may exist for an infrastructure augmentation strategy. Typically, permissible site discharge is governed by the capacity of the receiving drainage system. A cost-effective approach may be to augment downstream drainage infrastructure to improve capacity to cater for site flow. Such a strategy may reduce the amount of OSD required on the site and subsequently increase developable area.

# Appendix C – STORMWATER QUALITY MANAGEMENT

## C1 Introduction

Urban development typically increases impervious surfaces within a catchment, leading to potential increase in stormwater runoff. During regular rainfall events, runoff flushes pollutants that have been deposited during dry periods, resulting in higher pollutant loads reaching the receiving waters. To this end, rural runoff is of a higher quality than urban runoff.

Development within the City of Wagga Wagga involves converting rural lands to urban landscapes. As a result, stormwater quality management becomes critical. The impact of the pollutants depends on the pollutant, the sensitivity of the receiving watercourse and the concentration of the pollutants at the point of entry.

## C2 Objectives

1. Protection of aquatic and terrestrial environments
2. Minimise disturbance to catchments downstream of the study areas
3. Regular rainfall events do not adversely affect water quality
4. Compliance with legislation

## C3 Background

The major drivers of impacts on receiving waters that need to be considered in managing stormwater quality are as follows:

- Toxicants (heavy metals, hydrocarbons, pesticides, ammonia)
- Nutrients (phosphorus, nitrogen, carbon)
- Oxygen demanding substances (organic material (biochemical oxygen demand), ammonia, hydrocarbons, sulphides)
- Physical contaminants (suspended solids)
- Change in stream flow levels and frequency
- Microbial pathogens (enteric viruses, bacteria, protozoa, helminths)

- Aesthetic contaminants (organic and anthropogenic litter, hydrocarbon, nuisance algal-related scums, anaerobic-related scums and odours).

*(Source –Australian Runoff Quality 2006)*

Contamination of a waterway occurs when the concentration of an element is greater than natural levels. Current practice determines stormwater quality targets by assessing risk to the specific ecosystem to which stormwater runoff is being discharged.

"Trigger" levels, below which there is a low risk of harm to the environment, are being adopted instead of adoption of absolute values. If the trigger level is exceeded further analysis is required to determine ecosystem response.

The above concepts have been drawn from ANZECC Guidelines.

Table 3.1: Typical water quality values for urban runoff and guideline values:

| Variable (mg/L unless otherwise indicated) | Urban Runoff | Urban Guidelines |
|---|---|---|
| SS | 250 (3-1620) | <25 |
| BOD | 15 (7-40) | <2 |
| Lead | 0.01-2.0 | <0.025 |
| Zinc | 0.01-5.0 | <0.05 |
| Copper | 0.4 | <0.01 |
| Chromium | 0.02 | <0.01 |
| Cadmium | 0.002-0.05 | <0.0004 |
| Faecal Coliforms (orgs/100mL) | $10^4$ ($10^3$-$10^5$) | <$10^3$ |
| Total Phosphorus | 0.6 (0.1-3) | <0.05 |
| Ammonium | 0.7 (0.1-2.5) | <0.2 |
| Oxidised Nitrogen | 1.5 (0.4-5) | |
| Total Nitrogen | 3.5 (0.5-13) | <0.5 |

Note:
1. Table sourced from Australian Runoff Quality 2006
2. SS = suspended solids
3. BOD = biochemical oxygen demand

## C4 Stormwater Quality Management Controls

The above guideline values can be used to plan stormwater quality management facilities for each study area. Further investigations will be required to design an appropriate stormwater quality management system.

Targets and controls for Stormwater Quality management are to be selected in accordance with the procedure presented in Chapter 7 of Australian Runoff Quality – A Guide to Water Sensitive Urban Design.

Selection of stormwater quality targets is a two phase process.

- Phase 1 - select trigger values for stormwater runoff contaminant loads. This is undertaken by utilising the ANZECC / ARMCANZ water resources and management framework to identify environmental and use values of the receiving waterway. The trigger values represent a runoff quality level that must be met to in order to limit the risk to the values to acceptable levels.

- Phase 2 - estimate the Permissible Average Annual Export Load (PAAEL) for the catchment to be compared to the trigger values for the receiving waters. The design of stormwater quality measures will address the imbalance between the untreated PAAEL and the trigger values.

The above process recognises the differences in the way contaminants may enter stormwater runoff as well as the variable impacts contaminants may have on the receiving waterway. Furthermore by adopting trigger levels, a more efficient design process is achieved, by limiting the need for field sampling and laboratory analysis to situations where the risk of impact of the development has increased.

## C5 References

ANZECC / ARMCANZ - Australian and New Zealand Environment and Conservation Council/ Agricultural and Resource Management Council of Australian and New Zealand

ARMCANZ and ANZECC (1994), National Water Quality Management Strategy: Policies and Principals

Environment Australia (2000), ANZECC / ARMCANZ Guidelines for Fresh and Marine Water Quality, 2000

Engineers Australia (2006), Australian Runoff Quality A guide to Water Sensitive Urban Design

# Appendix D - Water Sensitive Urban Design (WSUD)

## D1 Introduction

Water Sensitive Urban Design (WSUD) integrates urban water cycle management with urban planning and design. WSUD drives the beneficial outcomes to the built environment by:

- Improving the urban landscape
- Reducing pollutant export
- Retarding storm flows
- Preserving the natural hydrological regime of catchments
- Reducing irrigation requirements
- Reducing demand on the potable water supply

In practice, WSUD aligns innovative water management technologies within the built environment. The goal of WSUD is to bring together the water environment and infrastructure service design at the early planning stages. WSUD is applicable to a range of projects, scaling from individual house lots to new communities.

Underpinning the approach to water sensitive urban design is that stormwater is to be managed as a resource and for protection of the environment.

## D2 WSUD Best Practice Approach

Implementation of WSUD utilises three strategies (1) stormwater quantity management, (2) stormwater quality management, and (3) stormwater as a resource. Stormwater quality and quantity management have been outlined in Appendix B and C respectively.

## D3 Stormwater as a Resource

Traditionally roof stormwater runoff is directed to the street stormwater drainage system. In response to climate change, particularly where many parts of Australia are experiencing severe and extended periods of drought, such an approach is considered to discourage water conservation.

As a result, a key strategy for WSUD is to capture roof runoff. A direct benefit of this strategy is the reduction of demand on the potable water supply. Typical uses for rainwater for non-potable water supply include:

- Toilet Flushing
- Irrigation
- Car Washing / Wash down water
- Manufacturing processes

- Air Conditioner Chillers

Stormwater re-use facilities can be provided on an individual lot basis or as a community-based scheme. The continuation of variable rainfall patterns is leading to more and more opportunities for stormwater re-use. Stormwater re-use also supports stormwater quantity management, by reducing the volume of stormwater runoff emanating from a site.

## D4 WSUD Planning and Design Tools

Several planning and design strategies are presented below to assist with the implementation of WSUD initiatives.

### D4.1 Open Space Networks

WSUD integrates drainage corridors into public open space areas. Furthermore these areas can function as conservation corridors. The alignment of the corridors would typically follow “blue line” watercourses or outer natural depressions in the topography.

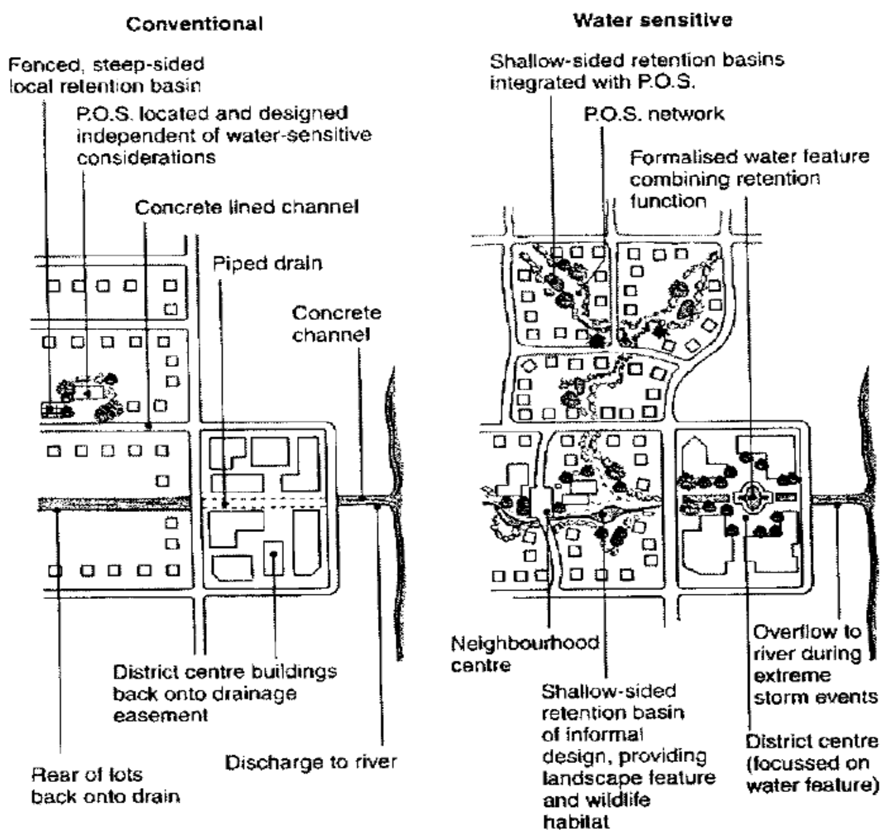
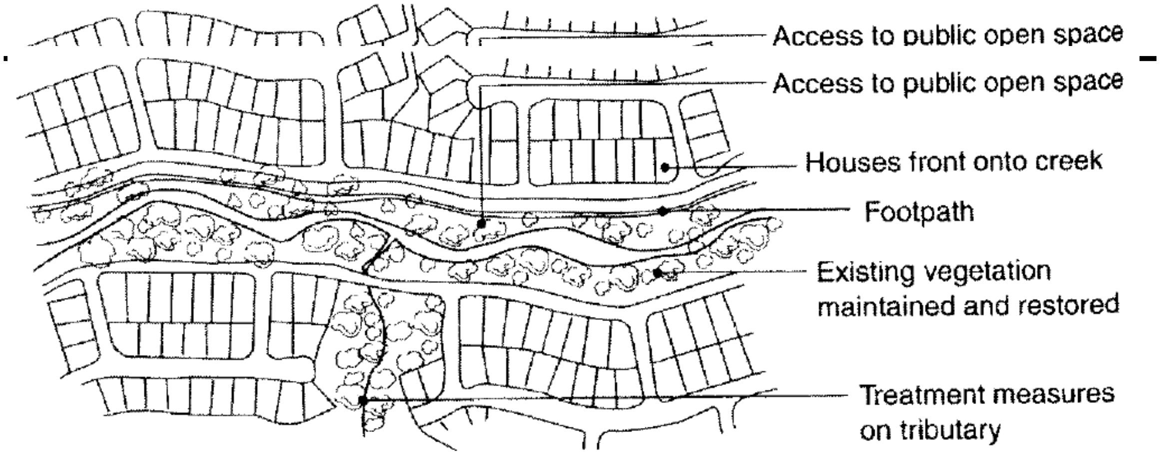



Figure D4.1 Open space network (Source: Engineers Australia 2006)



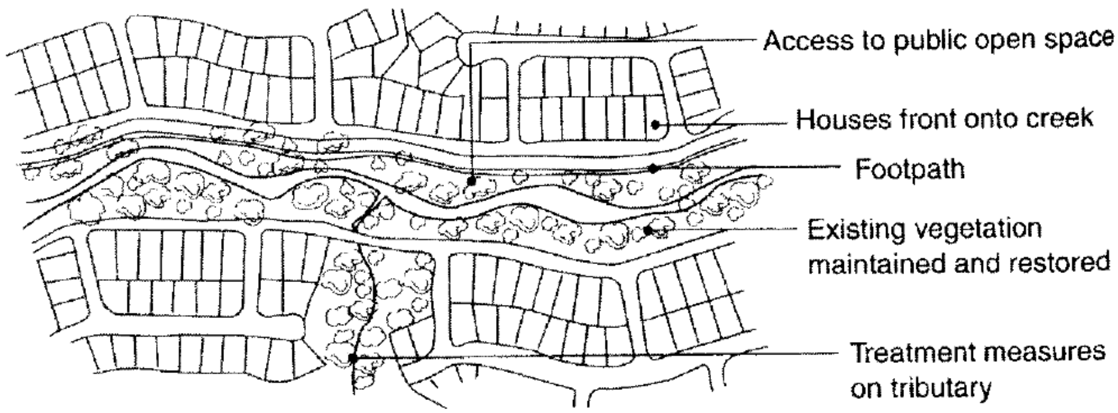




Figure D4.2 Integration of lots with open space corridors (Source: Engineers Australia 2006)

## D4.3 Road Layout

WSUD utilises the natural features of the site to develop the road layout. Roads are generally located beside open space networks / corridors. This serves to (1) enhance recreation amenity, (2) locate detention and pollution treatment facilities close to the discharge point / source.

This approach assists to reduce the surface area of roads. The concept is shown in Figures D4.2 and D4.3.

## D4.4 Streetscape

WSUD integrates vehicular and pedestrian requirements with stormwater management facilities. Typical methods include, zero lot lines, reduced frontages and placing stormwater detention and treatment facilities in road reserves.

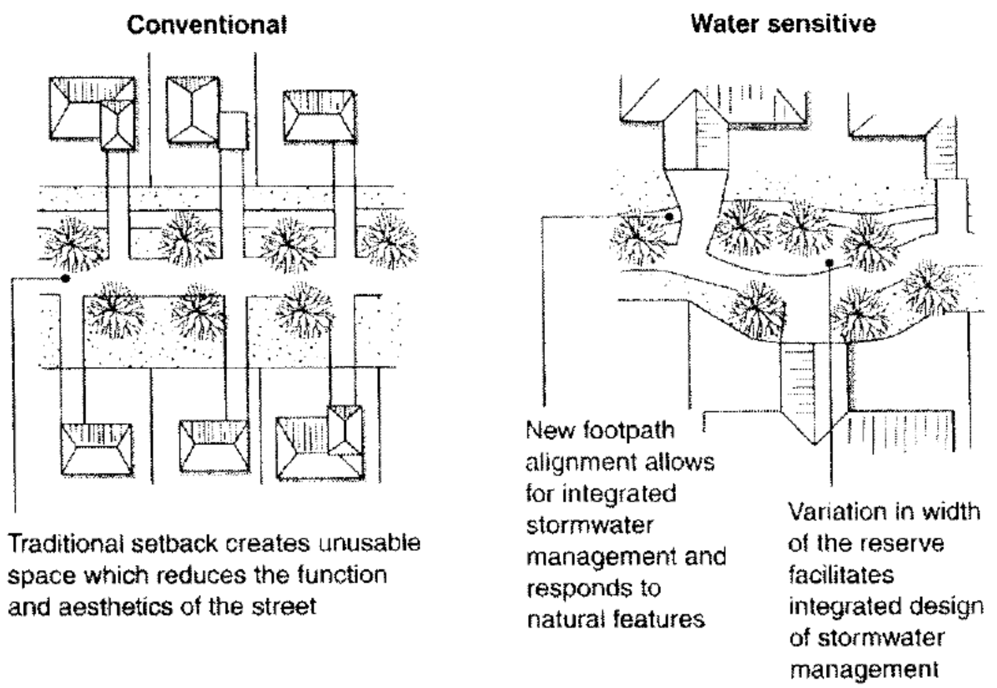



Figure D4.3 Conventional and WSUD road layouts (Source: Engineers Australia 2006)

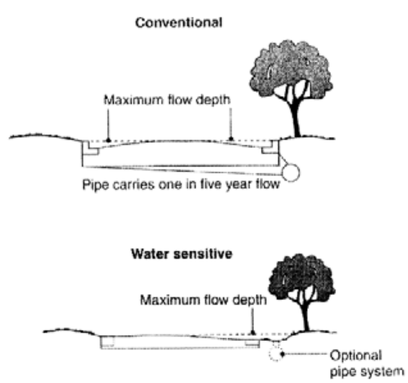



Figure D4.4 Conventional and WSUD road cross section (Source: Engineers Australia 2006)

## D5 Summary of Water Sensitive Urban Design Elements

Several of the commonly used WSUD elements are described in this Section. Typically a combination of these elements is used to manage stormwater from developed sites.

### D5.1 Sediment Basins

Sediment basins are designed to remove coarse sediments from stormwater runoff. A sediment basin removes particles by slowing water velocity to allow sediments time to fall to the bottom of a water column. Sediment basins are provided early in the treatment process and prevent downstream waterways becoming clogged.

Sediments basins require frequent maintenance. Maintenance activities included dewatering of the basin then removal of the collected sediment from the invert of the basin. Sediment basins can be designed to completely drain after a rainfall event or have a permanent pond.

Figure D5.1 Typical sediment basins (Source: Melbourne Water)

### D5.2 Bio-retention Swales

Bio-retention swales are bio-treatment systems located at the base of a swale. They provide treatment by filtering stormwater through a filter media such as sand. Furthermore, bio-retention swales detain stormwater runoff and act as a conveyance system (instead of pipes).

Bio-retention swales are commonly located in the median strips of roadways. Bio-retention swales offer efficient removal of nitrogen and other contaminants.

Bio-retention systems allow water to permeate through a filter media. The water is then infiltrated into permeable site soil or collected in an underlying perforated pipe / drainage system where impermeable soils are present. This arrangement can make bio-retention swales suitable for areas affected by salinity.

The performance of the bio-retention swale is enhanced by introduction of vegetation by prevent clogging and scouring of the filter material.

Figure D5.2 Typical bio-retention swales (Source: Melbourne Water)

### D5.3 Bio-retention Basins

Bio-retention basins operate in a similar manner to bio-retention swales, except that they do not convey stormwater. Bio-retention basins are “off-line” systems - where large flows are diverted away from the basin.

Bio-retention basins can be integrated into landscape areas and constructed in any shape or size to suit the application. Bio-retention basins work effectively by placing them at regular intervals in the roadway to form traffic calming devices or parking bays.

Figure D5.3 Typical bio-retention basins (Source: Melbourne Water)

### D5.4 Swales or Buffer Systems

Vegetated swales can be used to transport stormwater in lieu of pipes. The inherent interaction of stormwater with vegetated swales slows runoff and allows coarse sediment to remain within the catchment. In addition, swales can add to the aesthetic character of a development.

Swales are not suited to steep sites, as high velocities can result. Conversely swales constructed at flat grades (i.e. less than 2%) tend to become waterlogged. Trickle drains should be considered where soils have potential to become saturated.

Figure D5.4 Swale and buffer system (Source: Melbourne Water)

### D5.5 Wetlands

Constructed wetlands are vegetated water bodies that promote removal of pollutants from stormwater. Pollutants are removed by sedimentation, filtration and pollutant uptake by the vegetation.

Wetlands are made up of various zones, each with a different treatment function. Stormwater passes through each of these zones to obtain the desired water quality. Wetlands can provide a habitat for wildlife and can form part of recreation areas. Wetlands can vary in size to suit the site, land-use and level of treatment required.

Figure D5.5 Wetlands (Source: Melbourne Water)

## D5.6 Rainwater Tanks

Rainwater tanks provide two benefits to development. Firstly they encourage water conservation, and secondly they reduce the quantity of stormwater discharged to downstream waterways. Rainwater tanks also assist in reducing pollutant loads in stormwater discharge.

Rainwater storage can be provided on a lot by lot basis or as a community storage facility. Community facilities should always be considered in any project, as they offer a cost-effective means of providing rainwater harvesting to a large number of properties.

Generally, roof water is directed directly to rainwater tanks via a first flush flow treatment device. Surface water needs to be substantially treated prior to collection and re-use.

The size of the tank is dictated by the water demand of the services it supplies. If the service is totally reliant on supply from the tank, additional storage provisions need to be provided so that water is available during extended dry weather periods.

## D5.7 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) is the process where ground water supplies are recharged to counteract the effects of water extraction. ASR can also be adopted as part of a salinity management strategy. Typically excess stormwater from development (or land clearing) can be harvested, treated and injected back into the groundwater supply. The viability of an ASR scheme is dependant on the underlying geology of a development site and in particular the presence of natural aquifers.

## D6.0 References

Engineers Australia (2006), Australian Runoff Quality - A Guide to Water Sensitive Urban Design

Melbourne Water (2005), WSUD Engineering Procedures: Stormwater