BALLARAT REGIONAL

Water Sensitive Urban Design

GUIDEBOOK

Developed through experiences at Canadian Lakes Estate

Canadian Lakes Estate Masterplan

The project was made possible with funding from the following orginisations:

CITY OF BALLARAT
Roadcon Group
AUSTRALIA
State Government Victoria
CORANGAMITE CATCHMENT MANAGEMENT AUTHORITY

Introduction

The aim of this booklet is to encourage and equip both developers and agencies to feel comfortable using Water Sensitive Urban Design (WSUD), through Roadcon's experience in developing Canadian Lakes Estate in Ballarat during 2003. The project is the first residential estate in the region to fully integrate WSUD principles. Canadian Lakes Estate is intended to be used as a "benchmark" and a guide for all future development within our region.

During production of this guidebook, the Stormwater Technical Manual had just been released as a draft and a number of other industry reports on WSUD were available. Instead of repeating WSUD philosophy we decided to investigate and document the true issues experienced "on site during construction" at the Canadian Lakes Estate.

Included in this guidebook is a review of all aspects of design, construction & management of the WSUD systems integrated into development.

What is Water Sensitive Urban Design?

Water Sensitive Urban Design is a philosophical approach to urban planning and design that aims to minimize the hydrological impacts of urban development on the surrounding environment. When rain falls on roofs, roads, car parks and pavements, it has traditionally been transformed into fast flowing stormwater that causes erosion, build up of silt and pollution problems in the local environment and our waterways.

Previously, the environmental impacts of this form of stormwater have not been considered in the design of new urban developments. WSUD offers an environmentally friendly alternative to the traditional approach of collecting, concentrating and disposing of stormwater downstream.

WSUD more closely matches the natural water balance by:

- Slowing down the runoff.
- Allowing more of it to seep into the ground.
- Using stormwater treatments systems to remove pollutants.

The key planning and design objectives are to:

- Protect and enhance natural water systems in urban developments
- Integrate stormwater treatments into the landscape by incorporating multiple use corridors that maximize the visual and recreational amenity of the development
- Protect water quality draining from urban development

  Reduce runoff and peak flows from urban developments by employing local detention measures and minimizing impervious areas

WSUD recognizes that opportunities for best practice urban, landscape & architectural design along with stormwater management infrastructure are intrinsically linked.

Some typical stormwater improvement systems include the following:

Grass Buffer Strips are commonly used as a source control measure, particularly for management of road runoff, and are effective in the removal of coarse to medium-size sediments.

Vegetated or Grass Swales are open channel systems that utilize vegetation to aid the removal of sediment and suspended solids. Their removal efficiency is dependant on the density and height of the vegetation in the channel

Wetlands are an effective stormwater treatment measure for the removal of fine suspended solids and associated contaminants, as well as soluble contaminants. In some cases stormwater stored in wetlands can be employed for re-use opportunities.

Bio-retention Systems promote the removal of particulate and soluble contaminates by passing stormwater through a filter medium. The type of filter medium determines the effectiveness of the pollutant removal.

Ponds or Lakes use the temporary detention of stormwater to facilitate settling of suspended solids and include open water bodies (without significant shallow vegetated areas in the predominant flow paths) and ornamental ponds. Again in some cases stormwater collected can be employed for re-use opportunities.

Sedimentation Basins are open water bodies primarily for removing coarse and medium particles. This is achieved almost entirely by the temporary detention of stormwater to facilitate settling of suspended solids.

Gross Pollutant Traps are devices for effective removal of solids typically larger than 5mm.

When a number of these WSUD systems are used together it is often referred to as a stormwater treatment train.

Stormwater Management Scheme

An Introduction to WSUD at Canadian Lakes Estate

Canadian Lakes Estate is a 167 lot development situated in the Canadian Creek Reserve about 1.5km south of Ballarat's central business district. The project involves the construction of a flow control basin, a stormwater treatment wetland, the realignment & rehabilitation of the Canadian Creek & also the full implementation of WSUD throughout the residential estate.

Initial site investigations determined that both a number of constraints and opportunities existed with regard to urban stormwater management. The Canadian Creek suffers from poor water quality, as well as flow-induced erosion, caused by urban land use. The Creek also suffers from significant flooding issues associated with it, where up to 350 properties were under threat of flooding within this area. To tackle these issues; a partnership was formed between the development proponent the Roadcon Group, the City of Ballarat, the Department of Sustainability and Environment, EPA Victoria and the Corangamite CMA.

The following structural stormwater treatment elements were proposed as part of the estates Stormwater Management Scheme.

- A local stormwater treatment wetland to protect Canadian Creek from any impacts from the new urban development.
- Integrated flow control basin, to reduce flow-induced sediment mobilisation and habitat smothering, in conjunction with: modification of Canadian Creek channel to provide greater floodplain engagement, and thus promote trapping of sediment, reducing sediment transport downstream to Yarrowee River .
- Best practice Water Sensitive Urban Design elements throughout Canadian Creek parkland, and Canadian Estate residential development. All roads will be treated using vegetated swales and bio-retention systems.

How WSUD works at Canadian Lakes Estate

1. Local streets are the main component of WSUD. The way that a typical street works in WSUD can be seen below (Fig. D). 'Breaks' in the kerb and channel (Fig. A) direct stormwater runoff into the grass swales.
2. The grass swales slow down runoff, allowing seepage into the ground, filtering out pollutants. These swales act as drainage channels in periods of rain, transferring road runoff to an underground system of perforated pipes and gravel filled trenches.
3. Pipes under the swales carry the excess water through the system (Fig. B).
4. Water from house roofs is piped to the stormwater system (Fig. C).
5. Driveways are slightly 'dished' and aligned to follow the contours of the adjacent swales to allow water to flow across them. A small grated pit in each driveway crossover (Fig. C) is also included to prevent water 'ponding', however you can expect water to remain in the swales for a short period of time after heavy rain.
6. Drainage pits at low points collect surface runoff.
7. A bio-retention system in the central median collects and treats water in the central boulevard (Fig E).
8. In some circumstances stormwater captured in the grass swales is piped to a separate bio-retention system for further treatment (Fig G)
9. When stormwater flows to the rear of a lot, conventional pits are used to transport water via conventional concrete pipes to a bio-retention cell for treatment. (Fig G)
10. Roads reserves adjoining the Lakes have a one-way cross fall towards the lake which directs all runoff stormwater to be treated by the grass buffer strip before entering the lakes. A flush concrete edge strip is used instead of traditional barrier kerb (Fig F)
11. The Canadian Lakes provide more water quality improvement as well as an aesthetic and recreational amenity for residents.
12. The quality of the stormwater leaving Canadian Lakes Estate is of a much higher quality than that of traditional developments, thereby improving the quality of water in our creeks and waterways.

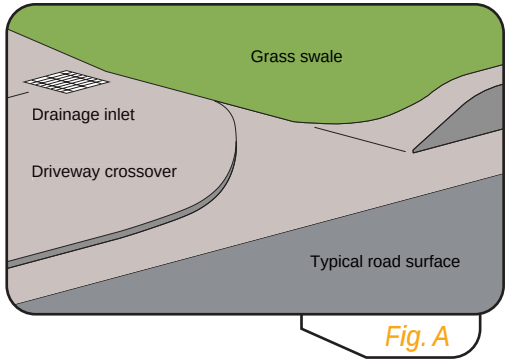


Fig. A

Typical kerb drainage

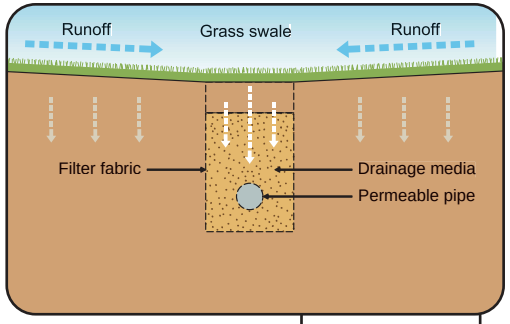


Fig. B

Indicative grass swale and pipes

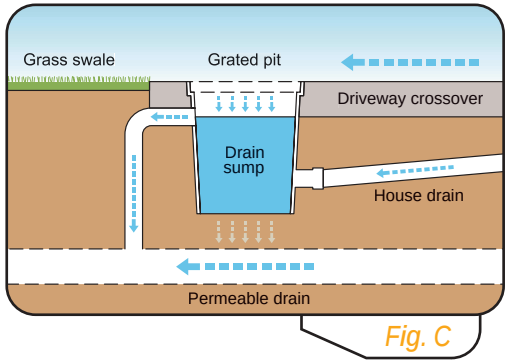


Fig. C

Typical drainage inlet in driveway

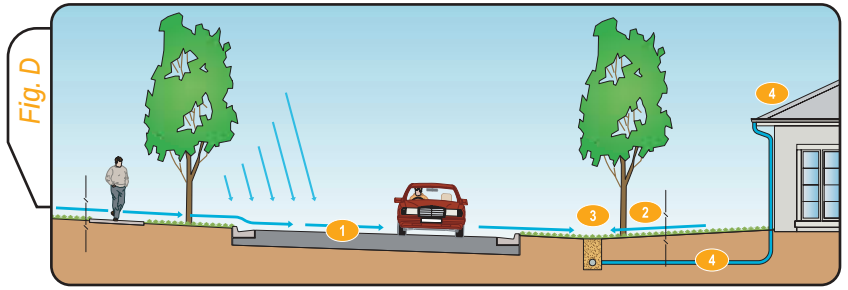


Fig. D

Typical local access street

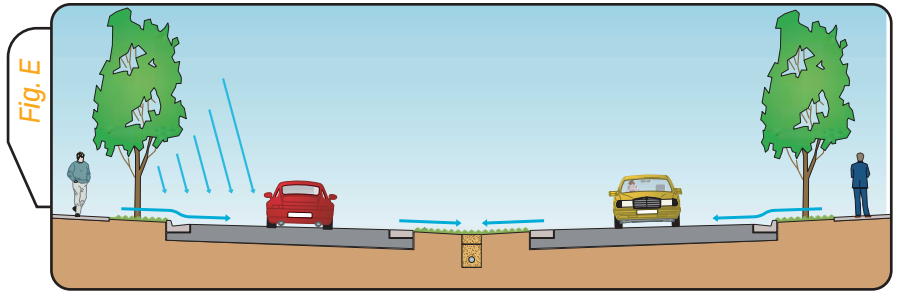


Fig. E

Typical cross section of boulevard with bioretention system

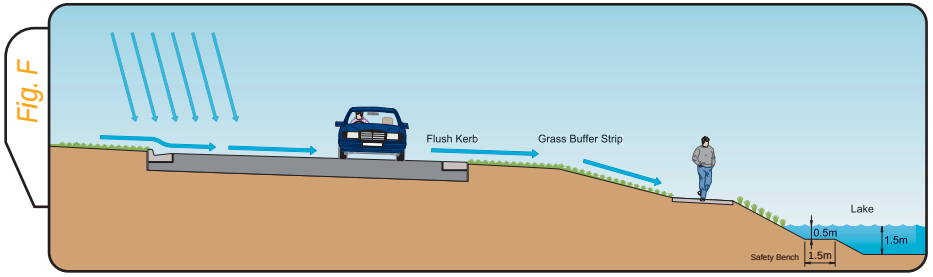


Fig. F

Typical cross section of street fronting the lakes

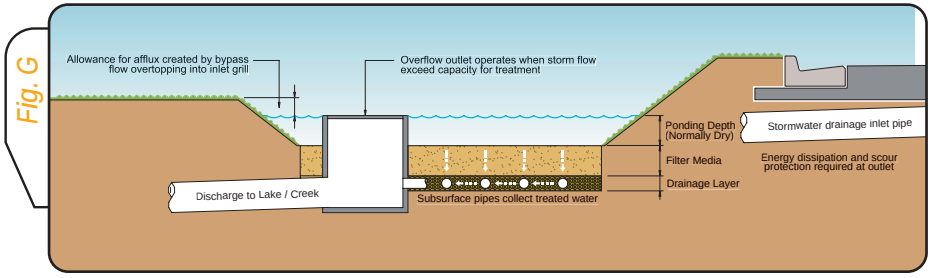


Fig. G

Typical cross section of end of pipe bio-retention system

Experiences in Civil Design of WSUD Systems at Canadian Lakes

Jason Frawley - Senior Civil Designer
Roadcon Group

The greatest issue I faced during the design of the WSUD systems was the lack of standard drawings and guidelines for clear direction in detailed design. As Canadian Lakes Estate was a demonstration site for WSUD in Ballarat and therefore never trialed before, we had to work in close colaberation with Council Engineers and our Water Resource Consultants to workshop design issues that would satisfy the Council's engineering standards.

Prior to the commencement of any civil design we met with our Water Resource Consultants and prepared a Stormwater Management Scheme for the site. The strategy & objectives for stormwater treatment was to exceed "best practice" design for the estate. We also visited a number of demonstration sites in Melbourne already implementing WSUD. We learnt of their stormwater management schemes and were shown how some of the WSUD systems had evolved during the life of the development. In our review of some of these systems we were able to implement further design advancements. Some examples of these are as follows

Driveway Crossovers

In previous estates the driveway crossovers were modified from traditional design to allow for stormwater runoff to enter the grass swale for treatment. This was achieved by rounding the bull nose of the crossover around to enter the swale.

We implemented a design that would allow a less concentrated flow entry point at the swale by providing a layback without any bull nose by integrating it into the laying of the kerb.

In Ballarat it is not a requirement for the developer to build driveways as it is in some other municipalities. Traditionally the developer constructs the road pavement, kerb and channel and then the concreter knocks out the back of kerb and lays the driveway at a later date. We had concerns that the contractors would damage the swale at this point. Due to the high sales rates, all lots sold out prior to construction of the kerb and channel being laid so we decided to contact new purchasers to determine their driveway locations. We then integrated laying the driveways into the kerb and channel. This was an unforeseen cost to the developer but provided us with the required quality control.

Grated pits

As a requirement of the stormwater management scheme, grated pits within the swales and bio-retention systems were designed to be permeable to allow for a second stage for water to seep out into the underlying subsoil. To maximize this we adopted slots running along the bottom and up the sides of the pit, and provided holes at each end of for further filtration via small lengths of subsurface drains. The design of the precast concrete pit evolved in consultation with a local manufacturer.

Experiences in Civil Design of WSUD Systems at Canadian Lakes *(continued)*

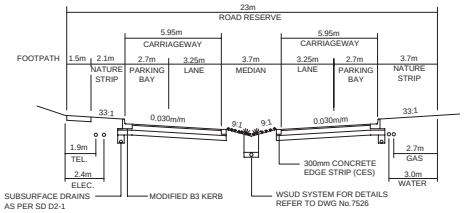
Other Experiences

We experienced difficulties in connecting house drains from the high side of the road to the low side swale for drainage. Council were initially unhappy with the idea of running the house connections underneath the road so shallow, so we specified a 150 diameter PVC imbedded in no fines cement, treated crushed rock for extra strength and durability under the road pavement.

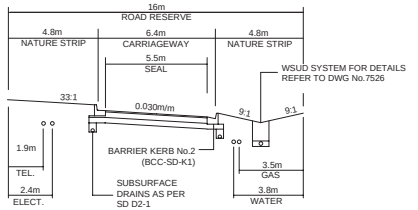
The hydraulic conductivity of the swale presented some issues when calculating drainage computations. We decided to design on a worst case scenario, and assumed that the swales were impermeable.

During design we also found that WSUD is not an economical system when a dual carriageway road is super elevated around a sharp bend. In this circumstance a swale is required in both the centre median and the low side nature strip. Given that it is advised to locate the swale on the high side of the existing surface profile to maximize your cross-sectional area for the 1 in 100 year flood path, significantly greater amounts of bulk earthworks are required in comparison to the conventional underground stormwater drainage system, where the road cross-fall would fall in the same direction as the existing surface. This is important to be aware of during the Urban Design phase so that roads can be designed perpendicular to the contour lines to minimize the increase of bulk earthworks. We also suggest that on sites with steep slopes, to employ other WSUD systems instead of the swale drains as the bulk earthworks may be excessive.

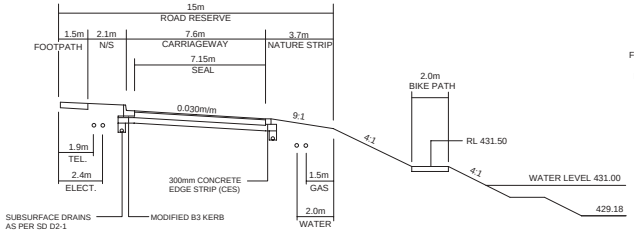
Finally, when determining cross sections of your street networks, be mindful of the width of the nature strips to allow for swales, service infrastructure, footpath and street trees. If we had our time over at Canadian Lakes Estate we would have preferred a greater clearance between service trenches. In doing so however, lot yield may be affected.



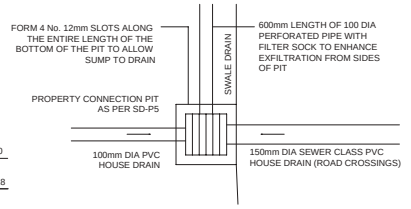
TYPICAL CROSS SECTION
BIO-RETENTION SYSTEM



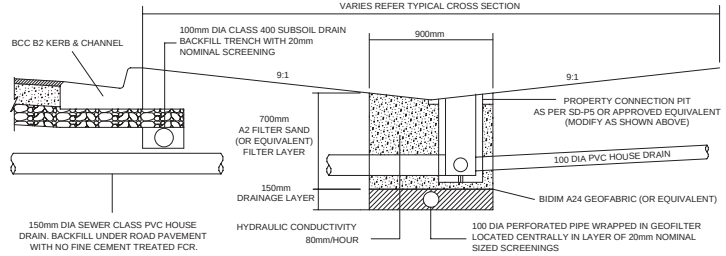
TYPICAL CROSS SECTION
GRASS SWALE



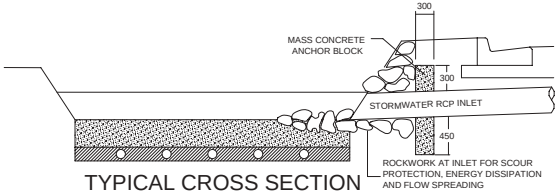
TYPICAL CROSS SECTION
GRASS BUFFER STRIP



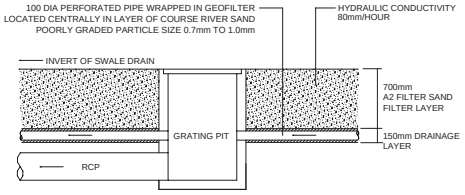
PROPERTY CONNECTION
PIT CONFIGURATION



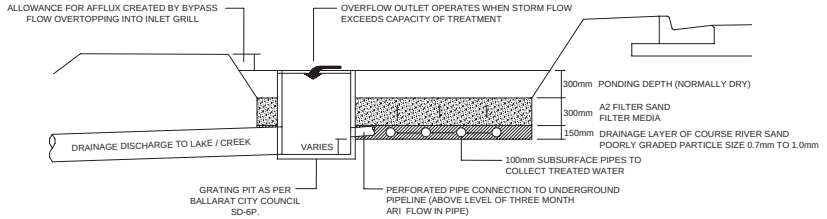
TYPICAL CROSS SECTION
SWALE AND BIO-RETENTION SYSTEM



TYPICAL CROSS SECTION
END OF PIPE BIORETENTION CELL
SHOWING OUTLET FROM UPSTREAM UNDERGROUND DRAINAGE SYSTEM



BIO-RETENTION TRENCH CONNECTION
INTO CONVENTIONAL DRAINAGE SYSTEM



TYPICAL CROSS SECTION
END OF PIPE BIORETENTION CELL
SHOWING INLET TO DISCHARGE PIPELINE

Experiences in Project Managing WSUD Systems at Canadian Lakes

Jason Martin - Development Manager
Roadcon Group

Following the endorsement of engineering plans by Council, I was able to start ordering materials for constructing the WSUD treatment systems. To achieve the appropriate hydraulic conductivity specifications for filter media within the swales and bio-retention systems, I investigated 2 different methods of construction:

1. Source the appropriate material to meet the hydraulic conductivity specification.
2. Create a bottom drainage layer and separate it with a geofabric textile sized to meet the specifications.

At Canadian Lakes Estate the latter was undertaken. This was primarily due to the difficulty in sourcing the media to suit the specification. In consultation with councils engineers we opted for a geofabric textile (sized to the specification) with a top layer of locally sourced filter sand.

Construction of the WSUD trench was best achieved following the installation of all services and construction of kerb and sub-base course rock. This did however create a problem of excavating very close to services. The exact level and position of the WSUD trench was easily obtained by working off the height and position of the kerb set.

Sedimentation removal following heavy rainfalls posed possible problems and as a result the WSUD system was top-soiled and seeded immediately following trench formation. Further control was achieved by the placement of hay bales at water entrance points and silt fencing to aid in decreasing runoff velocity. Swales were hydro-turfed or seeded in the first few stages however due to a poor strike rate we decide to go back and fully turf the nature strips with instant lawn. This was very successful with regard to sediment stripping but was costly.

We also recognized that future trades-people working at the site had the potential to damage the swale once our civil construction crew had left. To combat this we erected permanent "star picket" fencing to keep vehicles off the swales. We also sent letters to new land owners asking them to inform their builders and suppliers to abide. Access to lots was only available at designated driveway points.

WSUD Construction Sequence at Canadian Lakes Estate

Through our experiences we found it most economical to construct the swales and bio-retention systems as follows:

1. Place high side house drains underneath road
2. Then after kerb and channel are constructed
3. Establish offset and invert level
4. Excavate trench
5. Place subsoil drainage
6. Backfill with screenings
7. Lay geofabric textile
8. Install grated pits
9. Backfill with the filter sand
10. Place house drains
11. Shape swale
12. Place top-soil
13. Construct driveways
14. Lay instant turf, hydro-turf or seed
15. Construct protective fencing, silt fencing and lay hay bales
16. Constantly give maintenance to the swales

Experiences in Constructing WSUD Systems at Canadian Lakes

Jason Waight - Drainage Foreman
Roadcon Group

Generally the WSUD systems were trouble-free to construct however maintenance of the swales was ongoing and consumed a lot of time. (eg Silt fence maintenance, guard fencing, mowing, setting hay bales over the life of the construction)

In some instances we had difficulties matching the levels of subsoil drainage back to the stormwater pits due to its size. At Canadian Lakes Estate stormwater pipes and the swale trench were laid at the same offset from kerb (to fit in the nature-strip) and on occasions we had troubles due to the depth of the pipes running shallow and into the trench. I would suggest wider nature strips in the future.

We also experienced difficulties when a shallow sewer clashed with the depth of the swale trench on one occasion. Also sewer manholes, sewer inspection shafts and water hydrants had to be adjusted because they were laid level and as such sat proud of the 9:1 batter slopes of the swale.

With respect to laying Water, Gas and constructing street lights, offsets needed to be closely determined in order to avoid clashes with the swales. Within the main boulevard we have a bio-retention swale in the central median so street lights had to be offset from centerline which looked odd. Also be aware that services have to be placed a lot deeper so they did not travel through the swales. This caused a lot more work.

Driveways that were constructed as part of the WSUD swales were thicker than usual and reinforced with mesh since they had to sit over the trench.

It was difficult to find room for street trees within the nature strips due to the swale and service locations. We managed to plant them very close to the property boundaries and a root controller was used to inhibit the root system entering the swale trench.

We recommend on laying the 150mm house drains (high side crossing road) prior to Power and Telstra. We also recommend on keeping the power conduits below the house drains as it is likely at some point they will require servicing.

We also experienced a built up of silt at driveway entrance points due to the instant turf being laid flush to the top of the concrete driveway. We recommend setting down turf about 50mm from the top of the grass to allow for silt to enter the swale correctly and settle within the filter media as designed.

We found construction of the bio-retention cells to be very easy to and low maintenance. We have no reservations about using them again or recommending them to other developers.

Be mindful of your construction programme to planting times and landscaping. Plants play an integral part in stripping nutrients and contaminants but their survival rate in summer with water restrictions can be challenging. (Even if they are indigenous to the area)

Heather Pitman - Manager, Building & Assets
City of Ballarat

Council Engineering Perspective

There were a variety of concerns about the design and implementation of WSUD at the Canadian Lakes development along with the long term maintenance of the new drainage system. Generally design issues were worked through with Roadcon's designers with help from Ecological Engineering.

The experience on site

Driveway crossings need to be put in at the time of development. The design of these was modified on site to simplify the construction. Issues are occurring now with new owners of lots wanting to shift these crossings. The removal and new constructions need to be carried out under tight supervision to ensure that the swale drain is not damaged and continues to drain as designed.

The swale drains were turfed, which gave an excellent result with regard to grass cover, but left the swales high with respect to the crossings and this is causing silting up of the downstream side of the crossings. It is recommended that turfing should be mandatory for the swales, but that is laid at a more appropriate level.

With regard to the swales themselves there is concern about damage where services are altered, the effect of the street trees on the filter medium, the effect of silt running off building sites during the construction of dwellings and establishment of landscaping. The concern is basically that extra silt loading now will reduce the life of the filter medium.

There is also some concern about the grated pits at the ends of swale drains; the naturestrip at this point has been dished to capture the above ground stormwater. These dished areas can have quite steep grades and may cause problems to people walking along nature strips.

The swales have been fenced with star pickets and wire, and to date only one has been disturbed by the builder. This result is much better than anticipated.

The bio-retention cells have yet to perform as required. The outflows to date have not been within acceptable limits for stormwater. This is quite a concern.

Overall, the WSUD elements within Canadian Lakes, with the exception of the bio-retention cells, seem to be working reasonably well. There needs to be a recognition by the public of what the system is, and how it should be treated to ensure that the community gains the maximum possible benefit from this drainage.

The system will need to be monitored both for integrity and water quality over the next years before it can be claimed as a success. The whole of life costings need to be evaluated when there is sufficient data available to allow a comparison between the costs and benefits.

Melanie Emmett - Environment Policy Officer
City of Ballarat

Council Environmental Perspective

Site controls during building construction is seen as a major issue that needs to be addressed as a matter of urgency. Sediment control was considered poor during the construction phase of the subdivisional works with often sediment and erosion control being put in place retrospective of main rain events. Large areas of bare earth stripped of topsoil contributed to erosion and sedimentation issues at the site that can be identified by the brown ponds and lakes.

It is doubtful that water quality may not yet have improved at the site. Results of tests substantiating that water quality is in fact better than what would be expected from a conventional development would be useful.

The project however has been a positive for Roadcon to take on this type of development using WSUD that is yet to be tested in Ballarat. Although there has been many issues associated with the development, overall, I believe it has been a positive learning experience for all involved.

There is much to be learned from the experiences of this project both by the City of Ballarat and Roadcon. This project is seen as a positive for future developments.

The project has showed strong partnerships and displayed how both developers and regulators can work together for the benefit of the community and the environment.

Experiences in Project Management
at Canadian Lakes

Uldis Neilands - Waste & Environment Engineer
City of Ballarat

Summary and where to from here

There is to be a permanent position of Stormwater Coordinator created within Council to promote improved stormwater management within the City of Ballarat, including coordinating implementation of the Ballarat Stormwater Management Plan (BSWMP) and providing educational support in relation to WSUD and other water quality strategies.

A five year action plan has been developed for the implementation of the BSWMP which includes the creation of many projects around the Ballarat area (e.g. wetlands, litter traps and improved drainage systems) and the institution of educational programs.

To ensure the ongoing effective implementation of the BSWMP, a key action for the City of Ballarat and other key agencies is to establish a Stormwater Management Forum. This Forum will provide a formal mechanism to implement the SWMP and actively encourage information exchange and research in best practice in urban stormwater management. The Stormwater Coordinator will be responsible for coordinating the operation of the Forum.

Specifically in relation to Canadian Lakes, the Coordinator will provide advice and support to builders and homeowners - a service that will be transferred to other WSUD developments, as well as dealing with general development issues such as on-site control of litter and sediment on all development sites within the City. Appointment of the Coordinator is planned for October 2004.

Roadcon have been willing participants to this project who have worked well with Council and its officers to achieve an outcome to a project that is at the cutting edge of stormwater engineering standards.

Much can and will be learned from this project that will assist future developers in the Ballarat area that wish to implement WSUD into urban planning and design.

Ensuring the Integrity of WSUD Systems

Around 90% of sediments captured in the WSUD system will be deposited during the construction phase (which includes both bulk earthworks and house construction). Therefore it is essential that appropriate precautions are made to ensure that the WSUD swale can work efficiently. During construction Roadcon played an integral part in ensuring that:

- The erection of silt fencing was conducted around swale drains where lots were higher than the swale.
- Scouring within the swales was minimal by placing hay bales at entry points as a silt trap.
- Constant maintenance of the swales such as: fixing guard fences, removing surface sediment, reseeding, re-top soiling, weeding and mowing.
- Grated pit lids were covered with a geofabric layer to prevent sediments entry.

Furthermore, to ensure the continued efficiency of the WSUD system, extensive consultation with new residents was conducted informing them how to care for and maintain a WSUD system.

Through brochures, newsletters and signage (displayed around Canadian Lakes Estate) the new residents were educated on WSUD and subsequently the environment. Some of the suggestions that were offered to residents are as follows:

1. Avoid parking vehicles on the grass swales as this will compact the soil and reduce water infiltration. These areas were fenced off during the construction of homes, and residents were asked to ensure contractors and suppliers comply also.
2. To maintain the slope and grass on their nature strip to allow water to flow freely and seep into the ground.
3. Keep the swales & drains clear of any obstructions that may inhibit the flow of water, such as garden beds or mounds.
4. Mow the grass a little longer (say 4-6cm) so that it can retain its ability to trap sediment and particles.

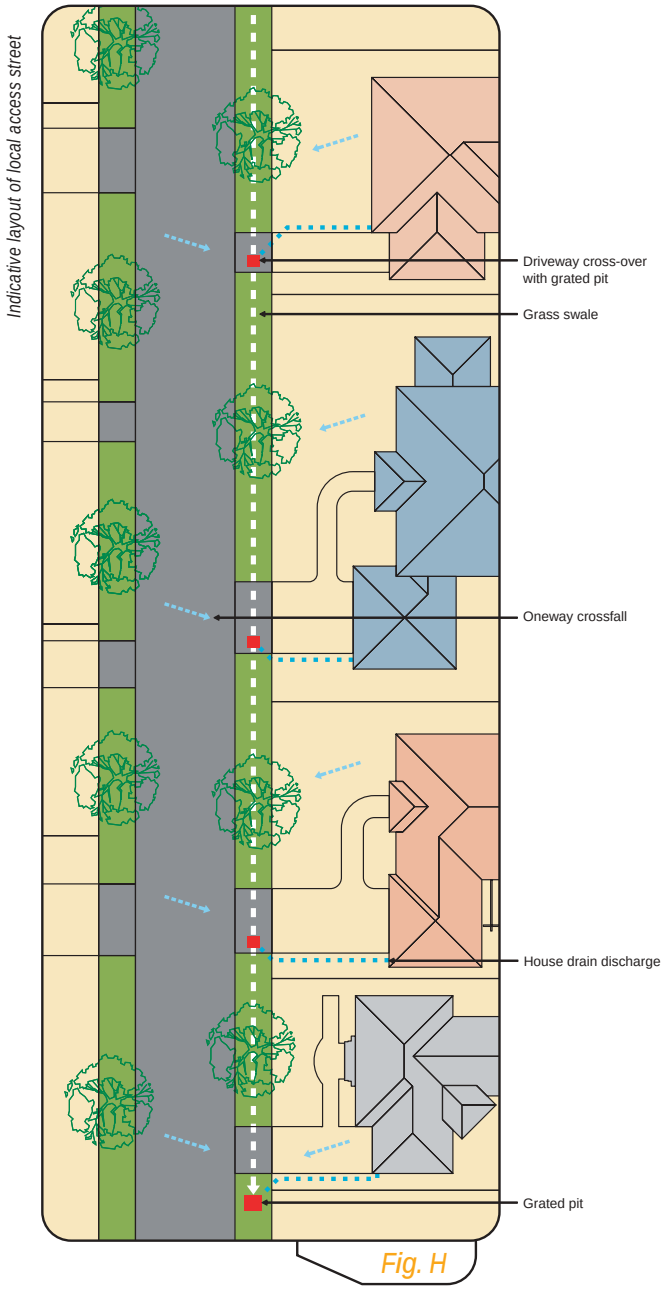


Fig. H

Summary

Recent practice and research has shown that WSUD is a well conceived planning and design concept that is an important component of achieving a more sustainable development. The technologies are well developed and reliable and have been employed in a variety of urban settings with strong acceptance by the community.

WSUD projects like the Canadian Lakes Estate have helped overcome the perceptions that WSUD technology is difficult to construct and costly to operate, and would be resisted by the community. The Canadian Lakes Estate was extremely successful and sold out within 3 months of release (167 lots). The City of Ballarat is committed to implementing sound urban and ecological design into all new developments within the Ballarat region.

Acknowledgements

Acknowledgements

Many people have contributed to the success of the Canadian Lakes demonstration site and in particular the following:

- The City of Ballarat's Environmental, Planning and Engineering departments. (Project management)
- The Roadcon Group for their innovative approach to urban planning and design, construction and project management. (Development proponent)
- The Ecological Engineering team (Stormwater Management Scheme)
- The Federal Governments Victorian Stormwater Action Programme (VSAP), the Roadcon Group, Department of Sustainability and Environment, Corangamite CMA and the City of Ballarat for funding the demonstration project.
- THA Landscape Architects (Landscape Design)

A Photo Gallery of Canadian Lakes Estate











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