Chapter 4
Low Impact Design Approach

Introduction

Stormwater management throughout the Auckland Region can be markedly improved by approaching stormwater in a different way from that taken in the past, where stormwater management has been largely considered stormwater disposal. This different approach is based on a conceptual understanding of stormwater which is more comprehensive in scope and addresses the full array of stormwater issues. These issues are important in order to maintain and protect Auckland's water resources, including maintenance of base stream flows, maintaining balance in the hydrologic cycle, reducing downstream sedimentation from construction activities, preventing flooding, and maintaining water quality and the ecological values which characterise Auckland streams and waters. This different approach further challenges us to maximise prevention, even before stormwater becomes a problem, and to avoid the commonplace highly engineered structural solutions that are expensive to build, expensive to maintain, and possibly ineffective for the purposes intended. Where feasible, this newer approach to stormwater management focuses on utilisation of natural systems and processes to achieve stormwater management objectives.

This different approach further challenges us to maximise prevention, even before stormwater becomes a problem, and to avoid the commonplace highly engineered structural solutions that are expensive to build, expensive to maintain, and possibly ineffective for the purposes intended.

This new approach is intended to work with site resources, as discussed in Chapter 3, and to enhance their functioning. It also builds on sediment reduction techniques discussed in Chapter 1. The end result is site design which protects and enhances existing wetlands, promotes the critical functions of floodplains, re-establishes or builds onto existing riparian buffer systems, and reduces downstream sedimentation while also satisfying sediment control and stormwater requirements.

In summary, the point of this new approach to stormwater management is to do more with less. We have defined this different approach as Low Impact Design, a design methodology, which includes an array of more areawide approaches as well as specific practices.

Low Impact Design Principles

Healthy Rocky Bottom Stream

Common to all of these approaches and practices comprising low impact design are five basic principles:

Achieve multiple objectives

Stormwater management should be comprehensive in scope, with management techniques designed to achieve multiple stormwater objectives. These objectives include both peak rate and volume control as well as water quality control and temperature maintenance. Comprehensive stormwater management involves addressing all of these aspects of stormwater. Complicated site configurations with multiple structural techniques may be required in some situations but the objective of low impact design is simple solutions to complex problems.

<u>Integrate stormwater management and design early in the site planning process</u>

Stormwater management, when it is provided, is often tacked on at the end of the site design process and almost always provides less than desirable results. For stormwater management objectives to be achieved, stormwater must be incorporated into site design from the outset and integrated into conceptual site planning, just as traffic considerations are. Stormwater impacts may, in some situations, even be a factor in determining the type and extent of a use which is to be developed at a site. Site developers and designers need to consider incorporation of low impact design practices into the overall site design process and attempt to not engineer them after the fact.

<u>Prevent rather than mitigate</u>

It may provide some benefit to define what is meant by prevention or mitigation. Prevention means to stop an adverse impact from happening or to make the adverse impact impossible to occur. Mitigation, on the other hand means to make an impact less intense or serious.

A key objective in stormwater management is minimisation of stormwater generating designs and avoidance of contamination occurring in the first place. This is a very different approach than the historic one. Historically, there has been a presumption that development must continue along traditional lines, and stormwater management has attempted to mitigate impacts to the greatest degree possible usually by use of a pond at the bottom of the hill or catchment.

Approaches to site design which can reduce stormwater generation from the outset are the most effective approach to stormwater management as they can significantly reduce impermeable surfaces. For example, effective clustering significantly reduces lengths of roads when compared to a traditional low density even sectioned approach. Arrangement of units with minimal setbacks reduces driveway length. Reduction in street width and other street modifications can further subtract from total impervious cover. These important elements of site design are rarely thought of as conventional stormwater practices, yet they achieve significant stormwater quantity and quality benefits.

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In the same regard reducing total site disturbance reduces the total amount of work required by erosion and sediment control practices during site development. Less site disturbance means less generation of sediments, which results in a lower potential for downstream sedimentation in streams and estuaries. Allowing existing vegetation to remain on sensitive areas such as steep slopes, or upstream of wetlands which may exist on site will reduce adverse impacts to downstream resources. As recognition of downstream receiving water impacts has increased, the potential for mitigation requirements to address the sediment impacts become more likely. Reducing the potential for sediment delivery would correspondingly reduce mitigation requirements and associated costs.

It is not being stated that mitigation practices will not be necessary as they will still be integral to site development in most cases. Rather prevention of impacts to the extent possible will lessen the reliance on mitigation practices to reduce or eliminate adverse impacts.

Manage stormwater as close to the point of origin as possible; minimise collection and conveyance

From both an environmental and economic perspective, minimising the concentration of stormwater and its conveyance in pipes costs less money (by reducing pipe diameter or elimination of pipes) and helps to maintain natural hydrology. Pipes, culverts, and elaborate systems of inlets to collect and convey stormwater, work against these management objectives and generally make stormwater management more difficult as such systems increase flows and rates of flows, with a result of worsening erosive stormwater forces.

Rely on natural processes within the soil mantle and the plant community

The soil mantle offers critical contaminant removal functions through physical processing (filtration), biological processing (microbial action), and chemical processing (cation exchange capacity, other chemical reactions). Plants similarly provide substantial pollutant uptake/removal potential, through physical filtering, biological uptake of nutrients, and even various types of chemical interactions.

LID is based on the positive notion that environmental balance can be less impacted as new communities are developed throughout catchments, if basic principles are followed.

Low impact design (LID) is based on a philosophy, a vision for the environment, that is neither pro-development or anti-development. LID is based on the positive notion that environmental balance can be less impacted as new communities are developed throughout our catchments, if basic principles are followed. LID means understanding natural systems such as essential water resources and making the commitment to work within the limits of these systems whenever and wherever possible. As stated above, LID is based on the recognition that stormwater is ultimately a precious resource to be managed carefully, rather than a waste product in need of disposal.

Approaches and Techniques

LID can be thought of in different ways. In this discussion, a broad distinction is made between those approaches which tend to manage stormwater largely through avoidance strategies versus those which are mitigative. An example of avoidance approaches would be reduction in imperviousness. In such cases, the generation of stormwater itself is avoided or minimised. This reduction in stormwater quantity may translate into a reduction in stormwater related contaminant loading. Furthermore, the cost savings associated with preventive approaches are obvious, although not always easily calculated. Total prevention of stormwater generation is not usually possible but a stormwater management system may be designed to maximise prevention. This would achieve both quantity and quality related management objectives more cost-effectively than other approaches.

Mitigative practices, on the other hand, are designed to manage stormwater after it has been generated. As such, mitigative practices logically have to collect and control stormwater, typically with some type of structure or even a series of structures. Mitigative practices are difficult to design to control both peak rate of discharge and volume increases, as well as to remove as many contaminants as possible.

LID approaches

LID approaches tend, for the most part, to be preventive but this is not always true.

Low impact approaches may include mitigative practices, such as swales or filter strips, which are less damaging to receiving systems than traditional approaches. LID approaches also tend to be broader in scope than traditional stormwater practices as they involve the entire site. Site design/clustering is one broad approach. Reduction in imperviousness also transcends the more focused stormwater management practice concept. The list of approaches included here includes:

- planning/zoning (building)
- clustering/lot configuration
- reduced imperviousness
- minimum site disturbance

LID avoids the basic issue of how much of what type of use is to occur at any particular site. The emphasis in this document is to define what we can do to improve stormwater management primarily on a site-by-site basis, assuming that development continues to occur. In those cases where conventional development programmes cannot use low impact design, density reduction is an option. Although development at the maximum allowable density has come to be the assumed norm in many cases, development at reduced densities may provide the economic use while balancing water and other ecological needs.

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<u>Low impact design practices</u>

LID practices include mitigative techniques which may be more structural in implementation. They encompass an array of biofiltration and bioretention methods such as vegetated filter strips and vegetated swales. These practices can and should be used with the approaches detailed above and with one another. Variations to these themes may emerge as greater experience is gained. It is important to be aware that there are far greater options available, and yet to be developed, than have been used in the past.

Clustering and Alternative Lot Configuration

Stormwater management is optimised when stormwater objectives are integrated into site planning from the earliest stage. The process translates into concentrating or clustering development so that the most environmentally sensitive areas of the site are left undisturbed or are subject to minimal disturbance, although there may be aspects of site design which cannot be readily incorporated within a conventional understanding of clustering. Most of the discussion here focuses on various aspects of clustering, that have evolved during recent years.

Clustering offers tremendous potential in terms of stormwater benefits and overall resource protection. Nevertheless, clustering does have limitations. Obviously clustering cannot address area wide catchment growth patterns which have important stormwater implications. Clustering is site specific but can relate to larger systems of open space by connecting the open space areas generated, cluster by cluster.

Although some density bonuses may be offered which increase density, clustering in a strict sense usually begins after the basic determination of how much of what type of use - a certain number of single-family residences, for example - already is to be permitted parcel-by-parcel. In some cases, parcels may be combined to produce a broader development pattern, but a typical clustering design should reflect the existing pattern of ownership if it is to function properly. In some cases, the clustering concept may be structured to include different types of development, including single family and multi-family concepts.

As a low impact design approach, clustering is important. From a stormwater management perspective, clustering minimises stormwater and contaminant loading generation from the outset and therefore is preventive in nature. To maximise positive stormwater effects, clustering works well when used in conjunction with other low impact design approaches and practices. In many cases, a tight clustering approach to site design facilitates these other approaches and practices and even makes them possible.

The challenge is to create a clustering system which maximises clustering benefits such as open space preservation even as developer incentives are maximised as well.

In order to achieve maximum benefit such as shown in Figure 4-1, substantial design flexibility must be maintained. Clustering can be made to work effectively on a small site or a large one, but clearly the standards imposed on a 30 hectare site need to be different, possibly significantly different, than the standards imposed on a 3 hectare site. Clustering may involve lot design and arrangement only. Or clustering may transcend lot design and even involve changing types of residences. The challenge is to create a clustering system which maximises clustering benefits such as open space preservation even as developer incentives are maximised as well.

If clustering is not mandated, incentives may have be provided to encourage its use. Many developers perceive clustered units on smaller lots as less valuable, so a density bonus provision is needed if the option is to be used (such as an increased number of lots). Adding to the problem is the fact that the clustering option typically requires all sorts of special consent processing requirements, which invariably requires more time, energy, and resources on the part of the developer. This additional effort, as will be shown, will result in significant cost savings during construction.

In addition, clustering may well require that a variety of provisions elsewhere in development requirements be modified. Setback provisions may have to be amended, as can be the case for any number of other dimensional requirements predicated on conventional subdivision design. Required street frontage, setback of the structure from the street, side and even rear yard setbacks become very different for cluster development then for conventional development.

Figure 4-1
Conventional vs. Low Impact
Site Development

Other important issues to keep in mind when considering clustering include:

- Are meaningful open space requirements established? Do these open space requirements vary with site size, type of use allowed, etc.?
- How is open space controlled and managed over the long term?
- Have water supply and wastewater provisions been incorporated?
- Have private property management systems been incorporated to the maximum extent feasible? Does the need for a private property management association discourage use of a clustering option?

Benefits achieved from clustering can be considerable.

- Reduction in imperviousness
- Reduction in contaminant loadings
- Preservation of special values and sensitive features
- Habitat protection and associated wildlife benefits
- Protection of aesthetic values
- Passive recreation and open space maintenance
- Reduction in costs, both development and maintenance

Although reduced imperviousness is dealt with separately later, it is such an important benefit from clustering that it deserves special mention. Holding all other aspects of the development constant (number of units, types of units), clustering significantly reduces impervious coverage. Impervious reduction is achieved mostly through reduced road construction and reduced driveway lengths. Given the direct relationship between imperviousness and stormwater generation, reduction in imperviousness can be expected to result in comparable reduction in stormwater generation, both total volume and rate.

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<u>Costs</u>

Clustering significantly reduces costs through reduced land clearance, reduced road construction (including kerbing), reduced pathway construction, fewer street lights, less street tree planting, less landscaping, reduced sanitary sewer line and water line footage, reduced storm sewers, reduced sizing or need for stormwater management ponds, and other related infrastructure reductions. The case studies done in Chapter 6 of this guideline will provide information regarding cost savings which could have been realised had a low impact approach been used, however Table 4-1 provides costs for typical land development activities. As can be seen, reduction in length or need for these activities or products can save on overall site development costs.

Table 4-1
Unit Cost Data (typical subdivision)
(provided by Harrison Grierson Consultants Limited)

Road costs/Metre		7.5 m. width	11.0 m. width
Subgrade trimming		$12	$18
Subgrade drainage (both sides)		$30	$30
Subbase (GAP 65)		$120 (250mm)	$215 (300 mm)
Basecourse (AP40)		$60 (100mm)	$132 (150mm)
Hotmix Seal (25mm)		$90	$132
Kerbing/Edging (both sides)		$70	$70
	Subtotals	$382	$597
Plus contingency		$38	$53
	Totals	$420/m	$650/m

Kerbing	
Kerb and channel	$35/m
Kerb only	$30/m
Footpaths	$40/m
Stormwater pipelines	
160 dia	$50/m
225 dia	$60/m
300 dia	$70/m
375 dia	$85/m
450 dia	$100/m
600 dia	$150/m
Manholes	$1,500 each

Site clearing
Difficult to cost due to possible large trees, removal of material off site.
$5,000 - $10,000/hectare w/ some tree removal and disposal on site

Erosion and sediment control
$5,000 - $10,000/hectare

Watermain
$2,000/lot depending on main sizes

Sanitary sewer
$2,500/lot

There are significant overseas data to detail significant cost savings by clustering development along with information relating to enhancement of land values. These data are not New Zealand specific and may not be applicable to local marketing conditions. It is the ARC belief that the same magnitude of costs and enhancements would be applicable to New Zealand but cost data will have to be locally generated to verify cost/benefits, this would provide developers and territorial authorities with a confidence in the figures before widespread implementation.

Local consideration of clustering

A number of District Plans were reviewed and interviews held with territorial authority staff on numerous development related issues. One of the issues discussed was clustering and the interviews provided the following comments:

- Clustering is not seen to be attractive to developers by one local Council.
- One District Plan does not currently encourage clustering and staff acknowledge that this concept needs further exploration.
- No medium density has been provided for but the Growth Forum will allow that within 800 metres of a transport node (PDC).
- Another council has opportunities for clustering in its urban expansion area. However staff anticipate problems with how the opportunity can be made available as there would be a need to amalgamate sites and require comprehensive development consents (NSCC).
- Clustering is possible through application with yet another council as long as the density and number of houses on a given area of land is not increased.
- In terms of complementary provisions, there are no explicit provisions for clustering in one District Plan but staff see the opportunity to encourage the concept in Structure Plan areas (FDC).

- Another council is promoting clustering for the purposes of landscape protection in its future urban development area. It also sees opportunities for intensive housing in greenfield areas with close public transport nodes. There is also potential for clustering in other zones and applications outside the intensive housing zone and they would be assessed according to 'fit' with intensity guidelines (which are currently under legal challenge)(MCC).
- Another council however does have District Plan provisions for cluster housing in rural countryside living areas. Minimum site size is determined in part by stormwater disposal and yard requirements. Design requirements include: site boundaries taking account of natural geographical features where possible; retention of existing vegetation; watercourses and natural features by locating them in common lots; lots to be located to reduce earthworks; maximising the use of common access drives; and houses to be grouped in nodes/clusters with a maximum of five sites. Individual access is generally not permitted whereas shared rights of way or jointly owned access lots are preferred (RDC).
- Officers of another council pointed out that clustering already occurs in areas of bush although the concept has not been taken up in other areas where there are opportunities in its District Plan. However it is being encouraged in an urban area and developers are looking at clustering on sites of 2.5 - 3 hectares (WCC).

Reduction in Setbacks

The issue of minimum setbacks relates to low impact design in important ways. Standard building setbacks from roads are found in most territorial housing codes, and these requirements must undergo some change if clustering is advocated. While councils specify yard setbacks there are generally opportunities for these to be relaxed.

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A review of District Plans and interviews held with territorial authority staff provide the following findings:

- An example of a minimum setback from the road is where this may be three metres with limited discretionary opportunity for the distance to be reduced (WCC).
- Another territorial authority allows buildings to be sited up to or on the front boundary in medium and high intensity developments, and relaxation of the six metre setback requirement in low intensity activity areas in new urban areas provided certain requirements are met (RDC).
- A third council has control flexibility in urban expansion areas to reduce front yard setbacks from five meters to one. Structure plan provisions include opportunities for minimum frontage requirements to large lot residential sites in excess of 4,000 square meters to be reduced from 24 metres to 10 metres (NSCC).
- Side yard setback provisions in one District Plan are required to be a minimum of six metres from the boundary or at least be screened from adjoining sites (WCC).
- Another council requires only 1.2 metres from side yards with allowable encroachments into yard setbacks in new urban areas where buildings will not be sited within any stormwater secondary flow path. Its rear yard provisions for the future urban zone are three metres (RDC).
- A third council has flexibility for reducing side (2.4 metres) and rear (three metres) setbacks via neighbour's consent or through a limited discretionary application. Buildings are sometimes allowed to be erected in the yard setback (NSCC).

Councils are required to take account of the New Zealand Building Code provisions for fire and other safety purposes. In residential areas, side yards may be one metre in circumstances where sufficient vehicle access is provided to beyond the rear point of each dwelling or where a garage or carport is provided for. The Code allows for some discretion for further encroachments if the building has achieved a satisfactory fire rating. Minimum separation distances of 1340 mm are required between buildings except where there is a common wall. Again, flexibility may exist and further encroachments may be allowed if Fire and Egress Officers are satisfied and the appropriate consent is obtained (MCC).

Reduction in Imperviousness

Imperviousness is an essential factor to consider in stormwater management, both from a quality and quantity standpoint. Site-by-site and catchment-by-catchment, increased impervious cover means increased stormwater generation with increased contaminant loadings as well. Consequently, actions which can be taken that reduce impervious cover become important stormwater management strategies.

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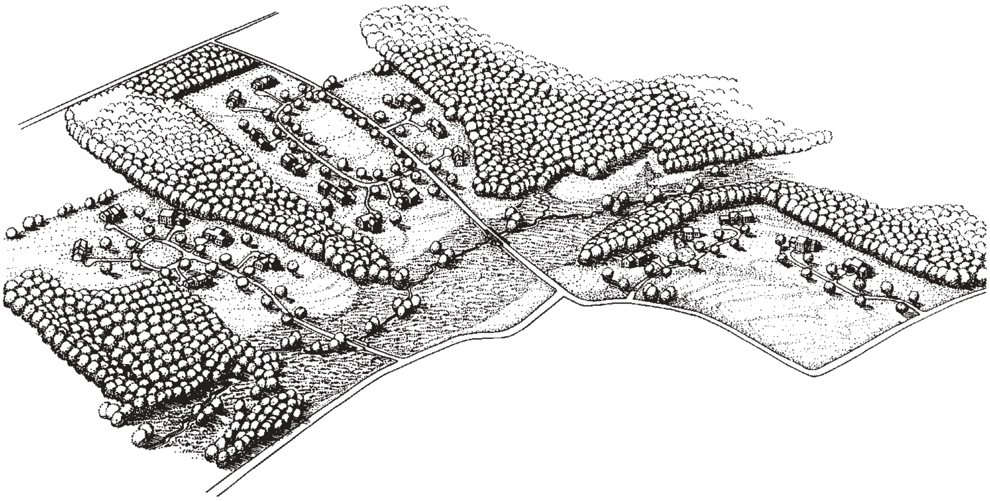
A variety of specific strategies to reduce imperviousness are described here. In many cases, planning for new street systems is often based on an hierarchical system where the function and use of the particular road can be linked to width and other characteristics relating to imperviousness. These low impact design approaches, in many cases, can stand alone and be used development-by-development, although reduction in imperviousness also can be used in tandem with other approaches and practices. As noted above, reduction in imperviousness also is achieved through other low impact design approaches, such as clustering.

Many councils have limitations on levels of imperviousness that can occur on residential developments but some see practical difficulties in monitoring/enforcement of such limits as individual property owners add impermeable structures after the building consent was issued.

A review of District Plans and interviews held with territorial authority staff provide the following findings:

- General development controls for residential areas within one council's jurisdiction require a minimum 30% (which can be relaxed by way of a limited

Figure 4-2
Minimal Imperviousness in a Subdivision



discretionary activity application) permeable surface area for each site for the purpose of enhancing on-site absorption of stormwater.

- Another council is addressing the issue of impermeable ratios in an Interim District Plan change; ratios will relate to lot size and impervious coverage. They are looking to 85% on lots of 425 square metres or less, and 65% on lots greater than 425 square metres to link with stormwater design (FDC).
- Other average coverage limitations in residential urban areas is 60-65% (PDC).

A major variable in considering imperviousness is the consideration of transportation which includes roads, kerbing, parking, and pathways.

<u>Roads</u>

Numerous demands are made on the road/road reserve resource. District Plan roading provisions have to reflect public demands for safe and efficient movement of pedestrians, cyclists, and motor vehicles, and for on-street parking opportunities. Other utility services such as water and electricity supply, sewage and stormwater disposal, and telephone have traditionally been placed within the road reserve.

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In all local councils, minimum street widths have been established which may be excessive and which may not reflect functional needs now or in the future. Having a minimum road paving width of 7.5 metres for "first order streets" may be excessive since these streets may serve low numbers of residences. This width is excessively costly to construct, requires expensive real estate, and creates far more stormwater than otherwise would be necessary. Because of the way in which so much development is configured, these streets are often just networks of cul-de-sacs specifically designed to exclude through traffic; in most cases such streets will not receive significantly increased traffic as an area develops. Consequently, traffic levels will never increase much beyond the traffic generated by the 15 or 20 houses lining the street.

Example of a Very Wide Street in a Residential Neighbourhood

Street width reduction offers considerable potential benefit in terms of stormwater reduction. For the very smallest access street or lane with fewer than 100 vehicle trips per day, decrease street width to five metres and gradually increase road width correspondingly with traffic increases. In conventional developments with conventional lots and house design, there is no need to provide onstreet parking, although if tightly clustered configurations are used, onstreet parking may be a desirable option and included in the design.

Road lengths are also an important issue. Road length should first be addressed at the Structure Plan, Neighbourhood Unit Plan level. Obviously overall dense patterns of development result in less road construction than do low density patterns, holding net amount of development constant. High density development and vertical development contrast sharply with the low density sprawl which has proliferated in recent years and which has required vast new highway systems in the urban fringe areas. Furthermore, the issue of concentration of development through increased density, while holding total amount of development constant, plays itself out at less macro levels of planning as well. As mentioned in the clustering discussion, road length is significantly reduced as tighter clustering occurs site-by-site. It is important to downsize streets, both their length and width, wherever possible.

Councils tend to follow engineering approaches to roads, parking, etc. with minimum road standards prescribed in their codes of practice. Potential opportunities for flexibility are not used as they could be by roading staff. One council envisages problems with an application requiring reduced road widths; developers want to reduce the road width reserve but that poses problems for utility providers. Council staff consider the implications of locating public utility services at the back of lots but concluded that services need to be located at the front of lots to facilitate future access for maintenance and eventual replacement /upgrading.

Reasons for not encouraging reduction in road widths include: insufficient parking, insufficient room for passing parked cars, people drive on berms, people try to drive both ways down one-way streets and the need for emergency vehicle access. Developments with narrower streets are perceived to be inferior if they reflect less than the minimum requirements. Staff from one council referred to the potential need for wider roads in a cluster development situation where there could be greater emphasis on the use of public transport (wider roads supporting public transit).

A review of District Plans and interviews held with territorial authority staff provide the following findings:

- Although councils have roading standards they do have flexibility to reduce road widths; these are assessed on a case-by-case basis as the effects need to be considered (MCC).
- While staff indicate that applications for reduction in road widths is not common, they would be considered as discretionary activities (RDC).
- District Plan provisions of another council proposes that the design of a road is to reflect its function and road widths can be reduced where less intensive use is anticipated (NSCC).
- A number of councils have been permitting/promoting narrower roads in some, particularly Structure Plan areas. This opportunity can arise in circumstances where subdivision design recognises the dominance of the residential environment by encouraging slower traffic speeds (WCC).
- District Plan provisions for subdivision in urban areas allow for dispensation of road and service lane standards if a better development can emerge. Situations where such dispensation could occur is when topography is steep or unusual, there is a benefit on amenities, or there are environmentally sensitive features (PDC).
- Another council could allow narrow roads if lot sizes were larger to accommodate on-site parking or if there were specially designed off-site parking areas for visitors. An innovative option could involve a cobblestone road merging with the subdivision with controls on entrances to lots. Although this would enable parking on private land, there would be a need to delineate public and private boundaries for maintenance purposes (FDC).

Kerbing immediately concentrates stormwater flows along the kerb and necessitates enclosed reticulation systems to convey the concentrated flow downstream.

<u>Kerbing</u>

The requirement for kerbing has a profound impact on stormwater flows. Kerbing immediately concentrates stormwater flows along the kerb and necessitates enclosed reticulation systems to convey the concentrated flow downstream. The end destination for these conveyance systems is either a stormwater facility or a discharge directly into a receiving system. Kerbing is routinely required as a component of site development with little flexibility provided.

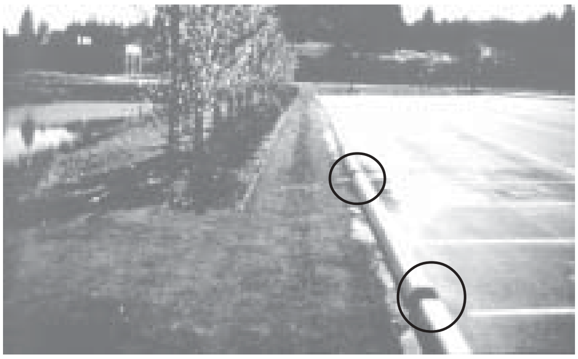
The provision of road drainage is generally engineering driven. Codes of practice tend to automatically assume the need for an enclosed system requiring road stormwater discharge to be managed.

A review of District Plans and interviews held with territorial authority staff provide the following findings:

- Kerb and channel is required on both sides of the carriageway in all urban subdivisions for some councils (PDC, MCC) and on roads in rural residential areas where it is required for consent. On roads without kerb and channel or on private ways on rural subdivisions, adequate drainage channels below subgrade level are required.
- Perceived hurdles to alternative approaches to road drainage is a community expectation of a neat appearance provided by kerb and channel (FDC, WCC).
- Public resistance arises out of people wanting their street to look like other streets (NSCC). Maintenance would be of major concern to council officers when evaluating 'neat and tidy alternatives'. The issue of maintaining roadsides may need to be considered in light of potential road reform where responsibility for local roads could move away from territorial authorities to private road network owners.
- One council is looking at piping and kerb and channel in medium density subdivisions (WCC). Another has an automatic requirement for an enclosed system for rural areas requiring the discharge to be managed.
- There is no apparent flexibility where it may be appropriate to enable non-concentrated overland flow (RDC). Introducing alternative methods of road drainage is possible in greenfield situations.

It is not the intention here to advocate elimination of kerbing in all cases but rather to allow flexibility for where that option may be viable. There are other alternatives if kerbing is considered as essential in a development, such as using kerb cuts to maintain dispersed flow which would then travel into a vegetated swale or across a buffer strip or into heavily vegetated areas. The key point is that flexibility is necessary to allow for stormwater management options.

Example of Kerbing Showing Kerb Cuts



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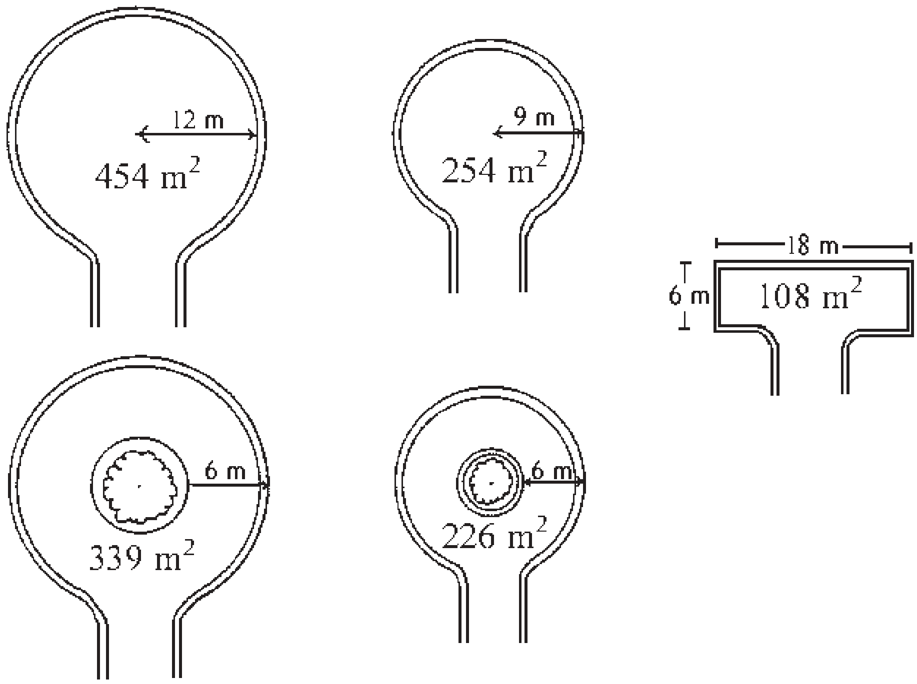
Turnarounds

Imperviousness can be limited in turnarounds as well. Large diameter circles at the ends of low density cul-de-sacs simply make no sense and create much more impervious area than is necessary. Figure 4-3 indicates turnaround options, culminating in the "T" turnaround which has the least level of imperviousness and is appropriate for low density cul-de-sacs where traffic flows are low. Individual levels of imperviousness are shown in the turnaround options having the dimensions shown in the figure. As can be seen the "T" turnaround option has an imperviousness less than 50% of the next smallest option.

Figure 4-3
Turnaround Options



Parking

Many different aspects of parking relate to stormwater problems, including parking ratio requirements as well as the design of parking spaces and their dimensions.

Councils typically establish minimum parking ratios, but rarely specify maximum parking ratios.

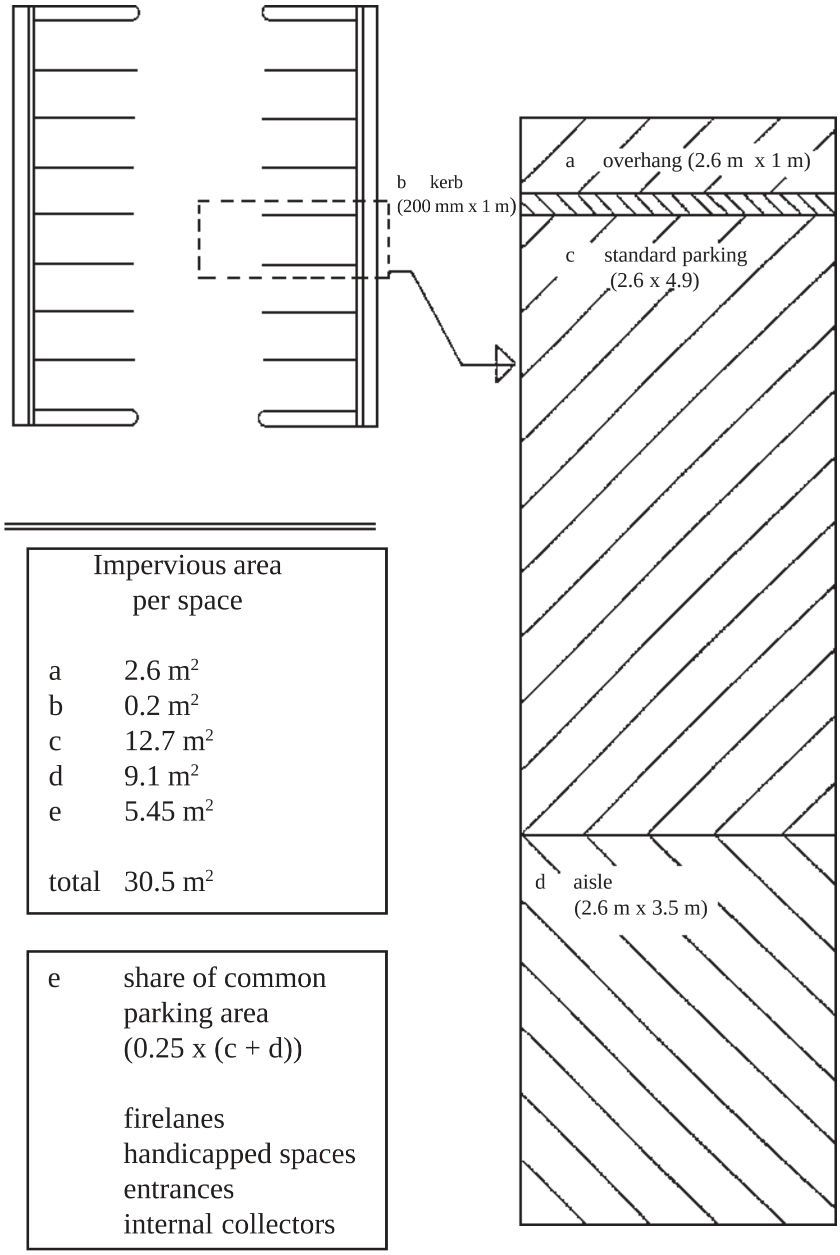
A discussion of parking as related to stormwater management links into larger planning issues quite quickly. But there are also low impact approaches to parking requirements which can minimise parking related imperviousness even where more conventional development modes are still utilised. The trend in parking ratios in recent years has been to increase these ratios, perhaps reflective of the general increase in land development and traffic associated congestion and the concern of councils to err on the conservative side. In some cases (primarily in commercial areas), minimum parking ratios are even exceeded by developers. Councils typically establish minimum parking ratios, but rarely specify maximum parking ratios.

It should be noted that adjustment of ratios must be done with care. Office parks, for example, are experiencing increasing employment intensities. As companies grow, more employees are hired; ratios of employees per square metre increase; cars increase and so does the need for increased parking spaces.

In terms of parking space design standards, this can be a significant contributor of overall site imperviousness. A standard dimension parking space can be 2.6-by-5 metres having a typical kerb overhang. When including the appropriate share of the parking aisle and the share of the common parking area, that impervious space can total over 30 square metres which is over twice as much as the actual parking area itself. (Figure 4-4). Reduction in the 25% shared area or reducing the number of parking spaces can provide a significant reduction in overall site imperviousness. Larger cars having a reduced turning radius are increasing the problem of parking lot sizing increases.

A variety of other design linked techniques should be evaluated, including altered

Figure 4-4
Examples of Parking Area Dimensions



approaches to spillover parking where less areal extent of paving is required (grass, metal, gobi blocks). Another simple technique is 1-way angled parking lot configurations which allow for a reduction in parking aisle widths.

The first parking-related objective of low impact design is to avoid inflated parking ratios. All parking requirements should be revisited, compared with adjacent councils, and compared with actual experience. Ratios such as one space for every 35 square metres of general floor area for offices should be revisited to see if it is necessary or can be adjusted downward. Depending upon the specific use involved, ratios driven by peak demand such as shopping centres may be able to be further reduced if combined with special parking overflow provisions.

The first parking related objective of low impact design is to avoid inflated parking ratios.

Secondly, maximise sharing of parking areas by creative pairing of uses wherever possible. Developers don't attempt such sharing because of the perception that officials would simply reject such a concept. Councils need to incorporate such sharing concepts into their requirements. Councils should also consider providing positive incentives for developers to utilize sharing options.

Driveways

Driveways are very much linked to configuration of the development. Conventional subdivisions have setback requirements as well as front yard/side yard ratio requirements and street frontage requirements. All of these specifications translate into a development mode which is very familiar and commonplace. Driveway length clearly must be equal to the house setback, plus required right-of-way. In addition, as lot sizes become large setback requirements tend to be well exceeded. Houses often sit considerable distances from the street and driveways become long. As houses have grown larger, car per house ratios have increased and larger driveways are again required. A standard four metre wide driveway will fan out into a two or three car garage. There may be additional paving required for out of garage parking. Although reduced density of development on any one site may give the appearance of some sort of improved environmental benefit, the larger site imperviousness expands quickly and is impacted negatively resulting in more stormwater problems.

Although reduced density of development on any one site may give the appearance of some sort of improved environmental benefit, the larger site imperviousness expands quickly and is impacted negatively resulting in more stormwater problems.

Solutions to driveway imperviousness would include reducing their length by locating the house closer to the road, using concrete strips rather than a continuous slab of concrete, or using metal strips as a substitute for concrete entirely. The metal will have a degree of compaction and still have surface runoff but the rougher surface will reduce flow velocities and it will require a larger storm to initiate surface runoff than would a concrete driveway.

Footpaths

Footpaths are an important element in community design and can also be a significant contributor of imperviousness generally being approximately 1.4 metres wide. Although many low density developments may not need footpaths, they are generally required. Councils tend to rely on their own codes of practice for guidance on the requirement and sizing of footpaths.

A review of District Plans and interviews held with territorial authority staff provide the following findings:

- Perceived problems with footpaths on one side of the street may cause a problem with bicycles being ridden on the verges. Narrow or no pathways may also discourage walking (WCC).
- Assessment criteria consider the extent to which footpaths aid pedestrian mobility, mail deliveries, and likely future use patterns (NSCC).
- Permeable pavers have been used in one council and the council is waiting to see the effect over winter. Pavers need to be

Example of a Dual Footpath, Providing Ever Increasing Impervious Surfaces

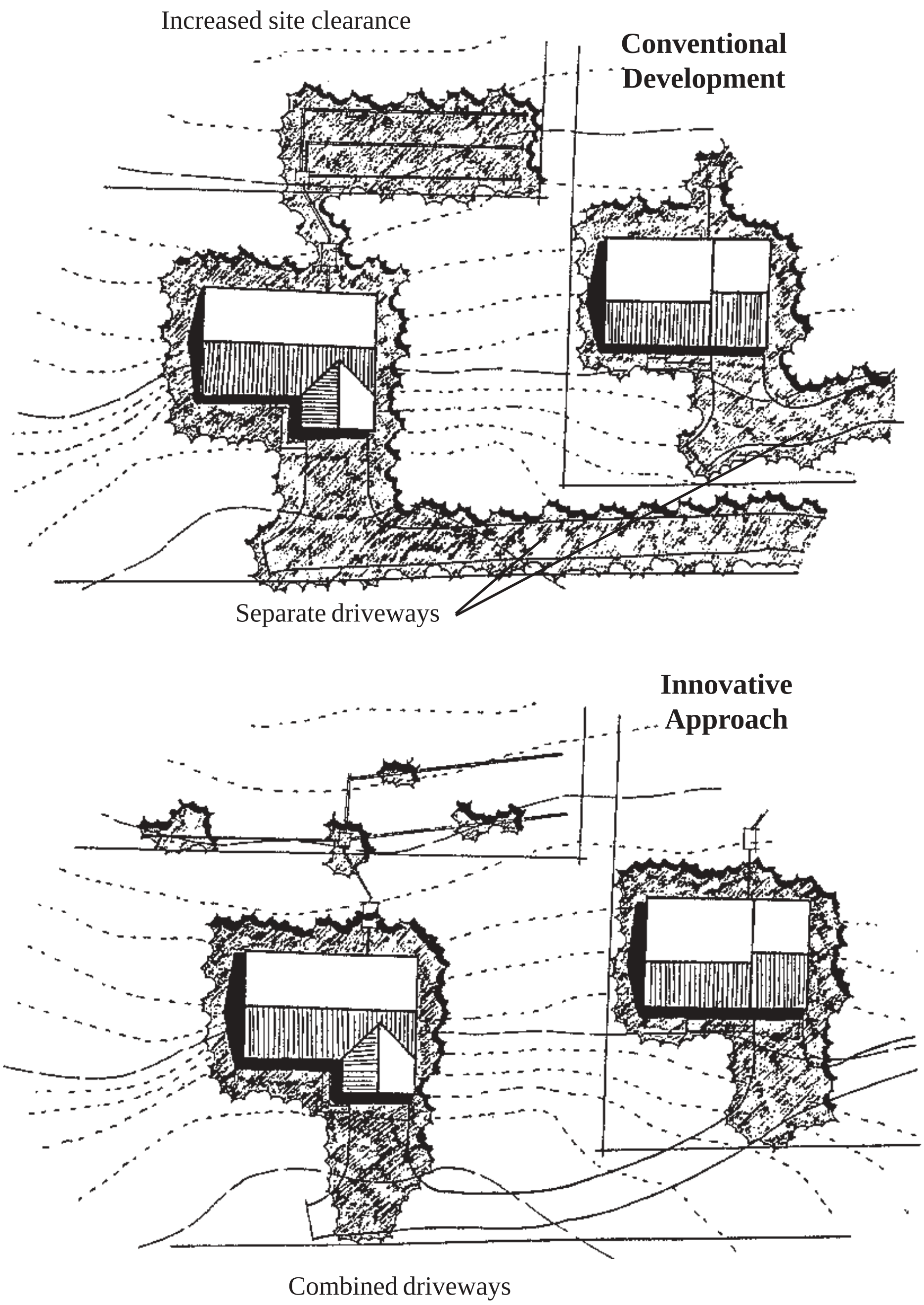
pushed so close together for safety purposes that they tend to lose their effectiveness. Permanent pavers require a porous layer below them making them very expensive and the paver units are imported from overseas. For these reasons, developers do not want to use them (WCC).

Low Impact Design Approach: Minimum Site Disturbance

Minimum site disturbance is an approach to site development where clearing of vegetation and disturbance of soil is carefully limited to a prescribed distance from proposed structures and improvements. In most cases, the concept is appropriate for sites with existing native vegetation, although existing vegetation can also be dune vegetation, pasture grasses, and coastal grasses. Tree cover need not consist solely of stands of mature native vegetation as scrub provides significant quantity and quality

Minimum site disturbance is an approach to site development where clearing of vegetation and disturbance of soil is carefully limited to a prescribed distance from proposed structures and improvements.

Figure 4-5



benefits as well. An example of minimum site disturbance is shown in Figure 4-5.

The objective of minimum site disturbance is to maximise existing vegetation and to minimise creation of an artificial landscape.

The objective of minimum site disturbance is to maximise existing vegetation and to minimise creation of an artificial landscape. At issue here are both construction phase impacts as well as the long-term operation of the development. By doing this, not only are the disturbed site impacts avoided as the result of substantial reduction in areas to be disturbed, but natural areas of vegetation are preserved, retaining all of their functions and ecological values.

The first step in developing a minimum site disturbance programme is to establish a variety of standards and criteria which define the approach.

- Establish a "limit of disturbance" (LOD) based on maximum disturbance zone lengths; such maximum distances should reflect construction techniques and equipment needs, together with the physical situation such as slopes, as well as the building type being proposed. For example, a four metre LOD distance may be workable in low density residential development, where a ten metre limit may be more appropriate for larger projects where larger equipment use is necessary. LOD distances may be made to vary by type of development, by size of site, and by specific development feature involved. A special exception procedure should be provided to allow for those circumstances with unusual constraints.

- Integrate minimum site disturbance requirements fully into the project review process. Procedurally, the LOD should be established early on in the reviewing process.

- Require the LOD to be staked out in the field for contractor recognition.

In addition, site disturbance can be minimised by locating buildings and roads along existing contours, orienting the major axis of buildings parallel to existing contours, staggering floor levels to adjust to grade changes, allowing for steeper cuts and grades provided that proper stabilisation and erosion and sediment controls are in place, and designing structures including garages to fit into the terrain, lot by lot.

Vegetated Filter Strips and Buffers

Vegetated filter strips and buffers are zones of vegetation, either natural/existing or planted, which are used to receive runoff in the form of sheet flow from upslope impervious areas. Strips may include vegetation ranging from grasses to forested areas. Vegetated filter strips may use existing vegetation or be planted during the course of development. Filter strips often must include some form of level spreading device to ensure an even distribution of stormwater across the vegetated area.

If filter strips can be integrated into design criteria so that small storms are controlled and properly distributed, with larger storms being redirected, the technique has excellent water quality benefits. While a filter strip may not eliminate the need for further stormwater controls downstream, it will enhance the water quality benefits by facilitating additional contaminant reduction.

Redirecting stormwater runoff from impervious surfaces to filter strips could be termed "hydrologic disconnection", with the objective here to minimise stormwater conveyance through widescale distribution close to the point of origin. In these cases, pathways and driveways and other impervious features are designed to drain evenly onto adjacent vegetated areas. Such areas can be lawn areas or planted groundcover, possibly even preexisting vegetation.

In terms of this document vegetated filter strips and buffers are combined, although there are some differences. One common distinction is that filter strips are often created or planted whereas buffers utilise existing vegetation. Another distinction is that filter strips are located as close to the source of runoff as possible, while buffers are typically techniques to protect sensitive environmental features such as wetlands or streams.

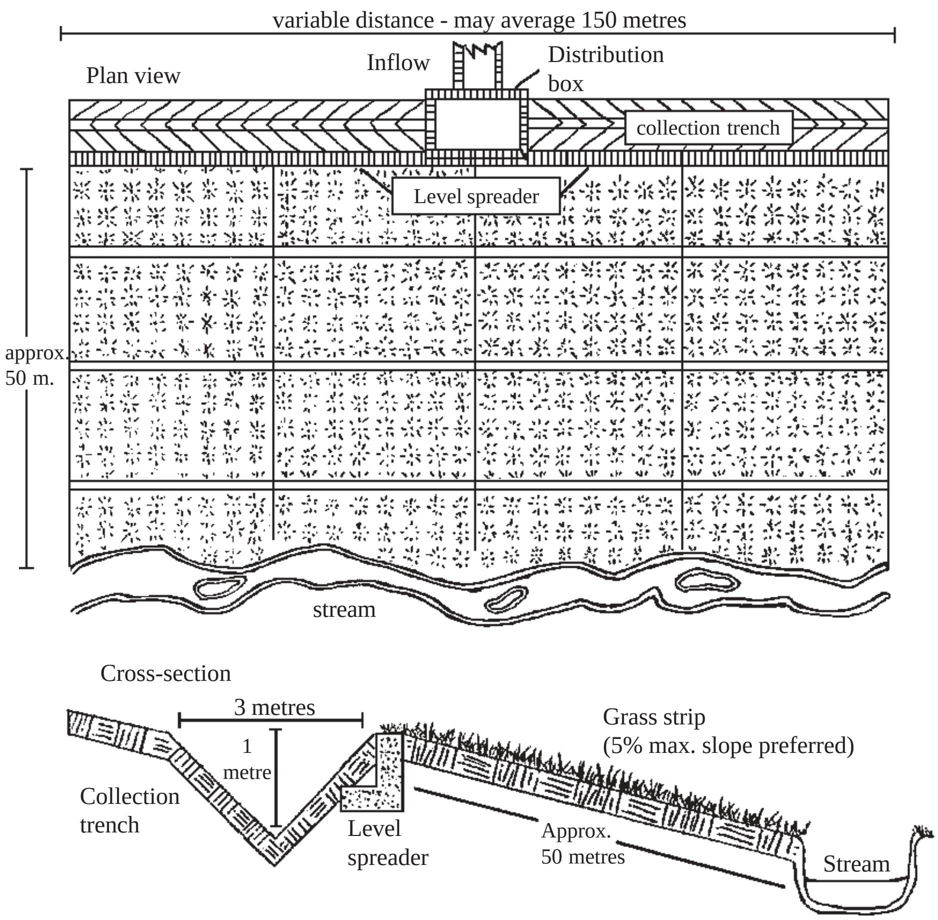
An excellent example of a buffer is the riparian buffer zone. This is where a sensitive stream system is buffered from stormwater runoff from adjacent developed areas. Although the full range of functions provided by the riparian buffer zone are more complex than the filter strip, conceptually the riparian buffer zone is an elaborate filter strip, as are other buffers provided around wetlands or any other protected resource.

An excellent example of a buffer is the riparian buffer zone.

Functional processes

Filter strips intercept stormwater flows before they become concentrated and then distribute the flow evenly across the filter strip. As the water travels across the filter strip it slows down due to frictional resistance of the vegetation to flow. Some portion of the runoff may infiltrate into the ground. As the flows are reduced various contaminants are removed through a range of mechanisms/processes. A schematic of a filter strip is shown in Figure 4-6.

Figure 4-6
Schematic of a Vegetated Filter Strip



Most filter strips have limited stormwater management capabilities and therefore are best suited for relatively low density development. Also, their functioning is maximised when only smaller storm events are treated. Critical to the proper design of filter strips is consideration of the following elements:

- slope
- level spreading of flows
- proper dimensions for contaminant reduction
- minimisation of velocities
- soil permeability or suitability
- avoidance of compaction and other related construction activities

The single greatest limitation to filter strip performance is channelisation and concentration of flow.

The single greatest limitation to filter strip performance is channelisation and concentration of flow. Contaminant reduction occurs as water flows through the vegetation. When flows are concentrated, the water quality function is short circuited. Concentrated flows can also cause significant erosion of soil and vegetation which would lead to degraded functioning of the filter strip.

Factors which can increase filter strip efficiency

- low slopes
- permeable soils
- dense grass cover
- long filter strip lengths (greater than 60 metres) increasing contact time of flow with the vegetation
- smaller storm events will have greater effectiveness than larger ones
- coupling filter strips with other practices

Factors which can decrease filter strip efficiency

- compacted soils
- short contact time of runoff to the vegetation
- large storm events
- short grass heights (less than 50 mm)
- steep slopes (greater than 5%)
- high runoff velocities (greater than 0.8 m/sec.)
- dry weather flow which would prevent grass growth and concentrate flows

Over time, filter strips may also accumulate sediment and other solids and clogging may occur. Periodic inspection can lead to early identification and treatment of maintenance related problems.

Detailed design of vegetated filter strips or level spreaders is provided in Technical Publication No. 10, “Stormwater Treatment Devices Design Guideline Manual” available from the Council.

Vegetated Swales

Vegetated swales are used as storm water conveyance systems. They are vegetated channels and may be located adjacent to a roadside, in a highway median, in a parking lot, or along the back or side of residential properties. Stormwater is directed into these channels and then conveyed to a stormwater treatment area or off-site. While their function is primarily for water conveyance they can have significant water quality benefits in addition to some water quantity benefits.

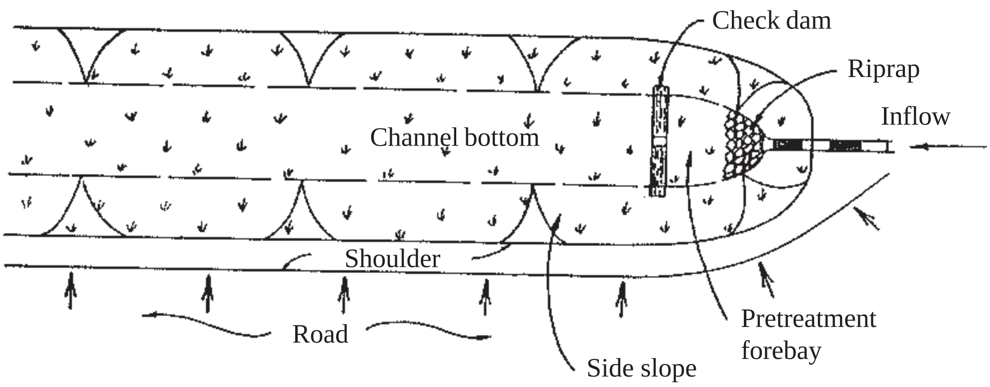
Vegetated swales can take the place of conventional stormwater conveyance/piped systems. Piped systems such as kerb and channel with catchpits provide no water quality function and in effect actually worsen receiving system impacts by increasing velocities and increased erosive forces. Although vegetated swales vary in their intended objectives and design, the overall concept of a vegetated swale is to slow stormwater flows, capture some contaminants, and allow for some reduction in the total volume of runoff.

Swales can act in two ways to affect stormwater flows. Firstly, conveyance of water in a vegetated channel causes a decrease in the velocity of flow. As the water passes over and through the vegetation, it encounters resistance. This resistance translates into increased times of concentration within the catchment and has beneficial effects on flood peaks. The result can be a reduction in habitat destruction and bank erosion that often is caused by peak flows from small storms. Some flow may infiltrate depending on the permeability and soil saturation. Secondly, water quality can be affected by passage through vegetation. All the physical, chemical, and biological processes perviously described can reduce contaminant loadings in stormwater. Total suspended solids are reduced as a result of decreased flow velocity. Vegetation can also directly absorb nutrients and utilise them in growth. A swale schematic is shown in Figure 4-7.

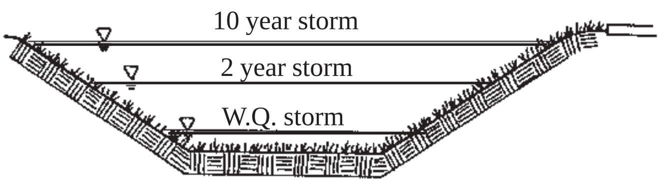
The overall concept of a vegetated swale is to slow stormwater flows, capture some contaminants, and allow for some reduction in the total volume of runoff.

There are specific factors that can both positively and negatively affect swale contaminant removal performance.

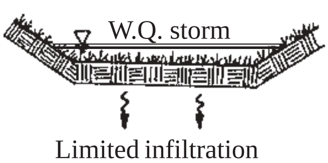
Figure 4-7
Schematic of a Vegetated Swale



Plan



Profile



Swale with Kerb Openings to Service a Carpark

Factors which can increase swale efficiency

- check dams to reduce flow velocities
- low slopes
- permeable soils
- dense grass cover
- long swale lengths (greater than 60 metres) increasing contact time of flow with the vegetation
- smaller storm events will have greater effectiveness than larger ones
- coupling swales with other practices

Factors which can decrease swale efficiency

- compacted soils
- short contact time of runoff to the vegetation
- large storm events
- short grass heights (less than 50 mm)
- steep slopes (greater than 5%)
- high runoff velocities (greater than 0.8 m/sec.)
- dry weather flow which would prevent grass growth and concentrate flows

Most sources concur that construction costs of vegetated swales are less than costs for conventional storm sewers, including kerbing, inlets, and conveyance piping.

Most sources concur that construction costs of vegetated swales are less than costs for conventional storm sewers, including kerbing, inlets, and conveyance piping. Maintenance costs for swales are relatively low. The primary objectives are to keep a dense mat of vegetation growing and to keep the swale free of obstructions such as leaf litter and significant deposits of sediment. These objectives can be accomplished by periodic mowing and inspection. Occasionally reseeding may be needed in areas that become bare. It is also necessary to discourage homeowners from cutting the grass too short.

It is important that swales be fully stabilised prior to accepting stormwater runoff. Swales that have been shaped but not stabilised will have greater stormwater flow velocities as a result of reduced channel roughness. Proper stabilisation will increase channel roughness and the plant root systems will reduce channel erosion potential.

Detailed design of swales is provided in Technical Publication No. 10, (previously cited).

Rain Gardens

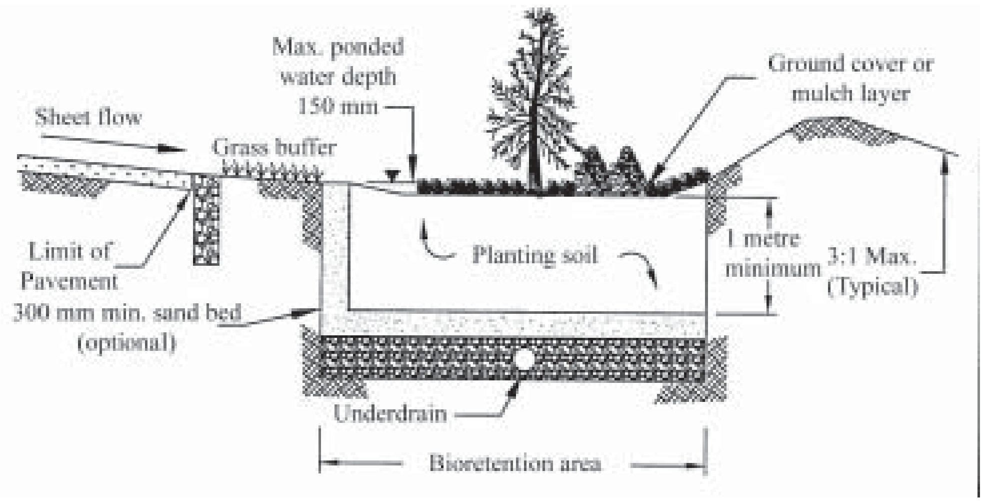
Rain gardens is a relatively new name given to use of a number of processes that are used in conjunction with one another. They use the concept of bioretention, a water quality practice in which plants and soils remove contaminants. Rain gardens are created in low-lying areas, with specific layers of soil, sand, and organic mulch. These layers naturally filter the stormwater. During the inter-event dry period, the soil absorbs and stores the rainwater and nourishes the garden's grasses, trees, and shrubs.

Example of a rain garden in a residential development

Rain gardens look and function like any other garden except they treat runoff and are designed with a layer of 100 mm of mulch, 600 - 1000 mm of planting soil, and vegetation (trees, shrubs). Limited monitoring of rain gardens have shown them to be very effective in removing contaminants. A standard detail of a rain garden is shown in Figure 4-8.

Rain gardens look and function like any other garden except they treat runoff.

Figure 4-8
Rain Garden Standard Detail



The rain garden concept can be used on individual home sites or as a public system. The main issue on their long term performance is the assurance of adequate maintenance responsibility. Over time, the systems may have reduced permeability that will increase surface ponding time. Another issue relates to maintenance of vegetation if the rain garden has an underdrain system which will be the case in many Auckland sites. The underdrain may cause the system to dry out more completely than would a system with no underdrain. This may necessitate watering of the vegetation on an as needed basis to ensure a healthy appearance.

Use of Natural Areas Including Reforestation and Revegetation

The low impact design approach involves utilisation of existing areas of vegetation, from forested areas to scrub vegetation to pasture areas.

The low impact design approach involves utilisation of existing areas of vegetation, from forested areas to scrub vegetation to pasture areas. The scale of this approach can be made to vary. In a micro sense, redirecting pathway and driveway stormwater runoff onto adjacent grassed or otherwise vegetated areas, illustrates this concept of natural area use. All such opportunities should be considered where redirection can be done without causing problems, such as concentrated flow increasing slope erosion.

For those situations where vegetation already exists use of that vegetation or enhancement of the vegetation is a good approach, Significant benefits can be gained also by reforesting or revegetating portions of sites which would improve an existing situation or expand a degraded resource.

Reforestation/revegetation includes planting of appropriate tree and shrub species coupled with establishment of an appropriate ground cover around the trees and shrubs so as to stabilise the soil and prevent an influx of invasive plants. The practice is highly desirable because, in contrast to so many other management approaches, reforestation actually improves in its stormwater performance over time.

Reforestation benefits relate closely to benefits cited in the literature on riparian stream buffer protection, although reforestation is not linear in configuration. Guidelines for reforestation are available through a number of sources including the following:

- A Guide for Planting & Restoring the Nature of Waitakere City
- Managing Riparian Zones: A Contribution to Protecting New Zealand Rivers and Streams, Volume 2: Guidelines, NIWA
- Various publications by Landcare Research
- Locations on the New Zealand internet provide assistance

Plant species should be selected carefully to match indigenous species which exist in the area and care should be taken to use species reflective of the combination of environmental factors which characterise the area. This enable species which will flourish in an appropriate site, as well as improving ecological health of streams and natural areas in the wider context.

Reforestation areas need periodic management, at least for the first five years. This will ensure good survival rates for the newly planted stock. The level of management decreases as the plantings mature. During the first 2-3 years, annual spot applications of herbicide may be necessary around the planted vegetation to keep weeds from outcompeting the new trees and shrubs for water and nutrients.

To the extent that vegetation of different types is already established, the already stabilised natural area offers various physical, chemical, and biological mechanisms which should further maximise contaminant removal as well as attaining water quantity objectives.

Water Reuse

The reuse of stormwater generated runoff has been integral to land development in New Zealand. Houses have and still use roof runoff for domestic water supply when public water has not been available. The effect of using roof generated runoff for domestic water supply has been to eliminate roof impervious surfaces from contributing stormwater runoff. This elimination of runoff reduces the total volume of stormwater runoff from land that has been developed downstream. If reduction in impervious surfaces is important to reduce overall site stormwater runoff volume, then water reuse can provide a significant stormwater management benefit.

If reduction in impervious surfaces is important to reduce overall site stormwater runoff volume, then water reuse can provide a significant stormwater management benefit.

To give an example of roof runoff volumes, consider a residential roof on a house covering 200 square metres. A one in ten year storm return period, 24 hour rainfall event for central Auckland is 120 mm. This depth of rainfall on the roof area yields 24 cubic metres or 24,000 litres of water. When considered on a catchment level where there may be 100 homes could yield more than 2 million litres. Reusing roof runoff for nonpotable domestic water uses such as toilets, laundry, and outdoor water usage can provide a significant stormwater benefit. If roof runoff was used for nonpotable domestic use, territorial authorities may require that back flow preventers be installed to avoid cross contamination of potable water supply if the two domestic uses were combined in one pipe system.

Waitakere City Eco Water distributes a brochure "How to Save Water" which provides some estimates of water usage within a household. Those estimates are shown in Table 4-2.

Table 4-2
Estimates of Water Use Within a Household

Home water use element	Percentage of water use (%)
Bathroom	28
Toilet	27
Laundry	21
Outdoor use	15
Kitchen	9

Toilet, laundry, and outdoor water use uses approximately 63% of all water use within the household and there is no reason why water supply for those uses cannot be provided by roof runoff. In addition to reducing the total volume of stormwater runoff, there may be economic benefits in reduced potable water consumption, and other broader benefits in reducing demand on public water supply. This would allow existing water supplies to last longer before needing to establish new sources and service a larger population base.

Water reuse is certainly beneficial from a residential consumption perspective but is also very beneficial from an industrial viewpoint. Water using industries having high levels of impervious surfaces can supplement water needs with roof runoff. Benefits of this will depend on their water demand, the ability to store water on site, and the uses for which the water is to be used.

Water reuse can and should be an important stormwater management tool. Reducing the total volume of stormwater runoff is essential if protecting the physical structure of streams is important. There are only three possible ways to limit the total volume of stormwater runoff, and all three of these ways are important to consider on a case by case basis.

Stormwater reuse, in becoming essential to site usage, can provide an effective long term solution to stormwater volume reduction.

- Limiting land use change and limiting impervious surfaces
- Infiltration of stormwater runoff
- Stormwater reuse

Limiting land use change is discussed throughout this manual and also must be considered from a catchment basis. Infiltration of runoff depends on soils, slopes, and land use, and must be considered carefully if long term performance is to be achieved. Stormwater reuse, in becoming essential to site usage, can provide an effective long term solution to stormwater volume reduction.

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