Chapter 5
Design Procedures

Introduction

The most important aspect of LID is that it achieves a new way of thinking about site design.

Low Impact Design (LID) presents a series of questions or check list items that must be addressed as the site design process is done. If site designers ask these questions and consider what their responses to those questions are then LID is accomplished. The most important aspect of LID is that it achieves a new way of thinking about site design.

The approach provided here is simplistic and attempts to avoid the temptation to become overly detailed and complicated. There are thousands of variations to LID and no amount of detail will cover every situation. The case studies provided in Chapter 6 will provide an example of how LID should be undertaken from a minimum earthworks strategy for erosion and sediment control and from a stormwater management standpoint.

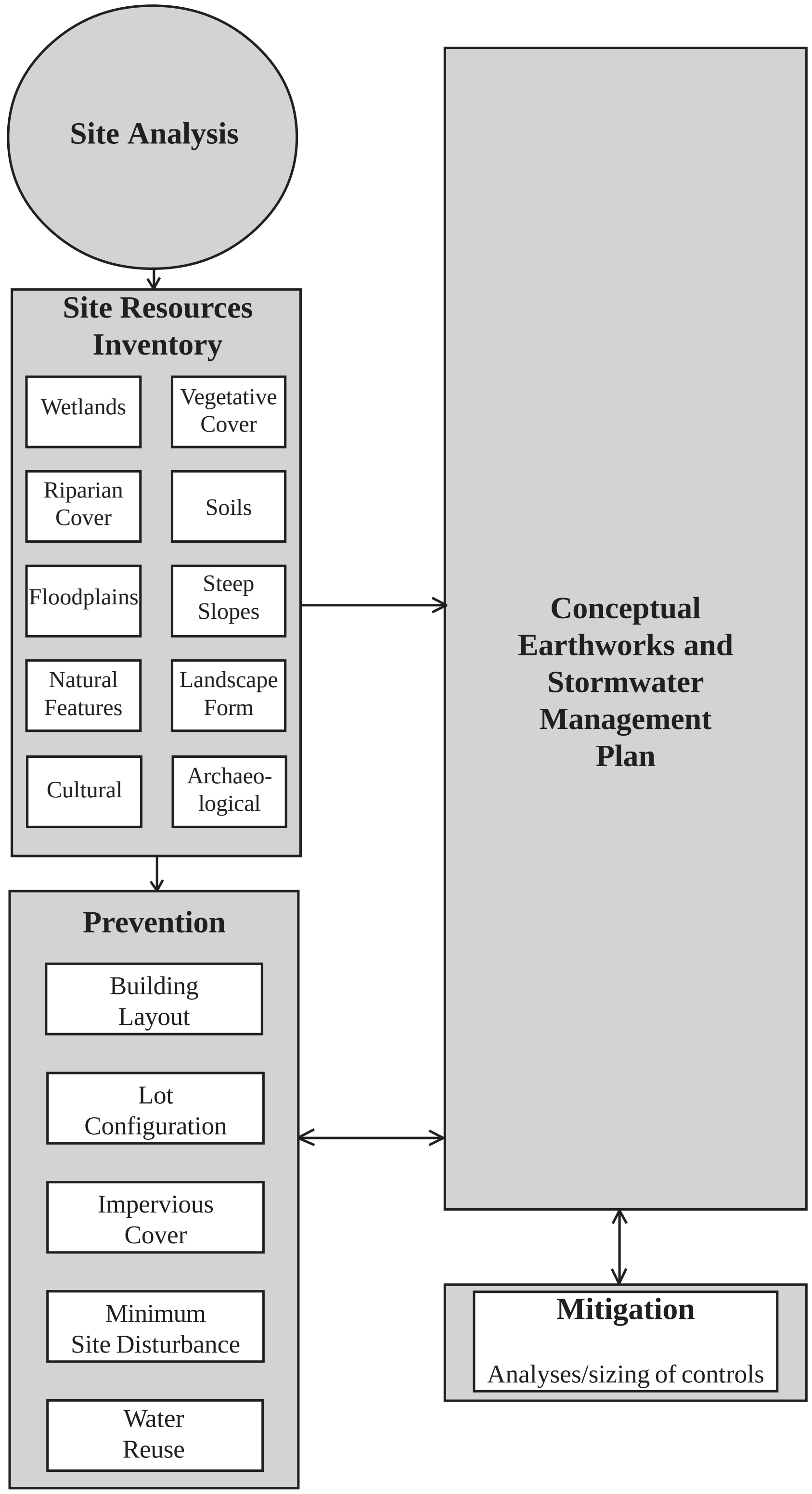
In terms of approach in this chapter, individual components of site design will be discussed with a checklist provided for each section. At the end of the chapter, an overall LID checklist will be provided which covers all of the individual components.

Design Procedure in Overview

As design procedures go, LID is simple as shown in Figure 5-1. The procedure is based on using an analysis of existing site conditions as a baseline from which to start from. These existing site conditions provide an inventory of the full range of natural systems - water, soil, geology, vegetation, habitat - as well as cultural and archaeological factors. These systems range from the very macro in scale for resources of Regionwide significance, down to micro scale site specific conditions such as steep slopes or the presence of first or second order streams. The more this complex system is documented and understood from the start, the better the earthworks and building programme can be fitted on the site with reduced impact. Extra design effort up front will pay important dividends in the long run. LID requires a major departure from the conventional mindset of site disturbance and stormwater disposal, which is a reactive approach with end of the line process forcibly imposed through a consent requirement. LID is based on understanding natural system opportunities which enable us to achieve essential stormwater quantity and quality management objectives integrated into the development design from the very beginning.

LID requires that a series of questions are answered which, from an earthworks and stormwater perspective, are preventive in nature. If these questions are addressed, the reduction of stormwater runoff can be maximised. In most situations, sediment control and stormwater mitigation will still be required due to site disturbance and the increased volume and peak rates of runoff. On site mitigation efforts in stormwater management should attempt to use less impacting forms of management such as incremental stabilisation and vegetated swales or filters where practical, but more structural forms of management such as ponds or wetlands will still generally be

Figure 5-1
Low Impact Design Procedure



required although their sizes will be reduced from the conventional site development approach.

A relevant analogy to the benefits of LID is the relationship that erosion control has to sediment control. Erosion control during construction is preventive in that it reduces the total amount of sediment generated. Sediment control attempts to reduce downstream delivery of sediment through the use of mitigative practices. LID is similar to erosion control as it is preventive. Conventional stormwater management is like sediment control in that it attempts to reduce adverse impacts rather than preventing them.

This integration of erosion and sediment control and stormwater management issues into site design from the start of the design process is essential to LID.

The most important aspect shown in Figure 5-1 is the conceptual earthworks and stormwater management plans being done concurrently with the entire site design process. All of the preventive and mitigative steps link into the conceptual process. The building programme, site design including earthworks, and stormwater management concept are integrated and optimised. This integration of erosion and sediment control and stormwater management issues into site design from the start of the design process is essential to LID.

Site Analysis/Factors Inventory

A site analysis/factors inventory is provided which contains information that, if gone through, ensures that LID has been considered and incorporated to the extent possible. The analysis/factors is presented here in the form of a checklist for ease of use. The checklist should be completed to demonstrate that the individual items have been considered as a component of site design. Other than the yes and no questions, the others have a check (✔) to show their consideration or inclusion, as appropriate.

<u>LID Checklist</u>

Information to be provided in a narrative form or on a plan:

_____The surrounding land context (rural, urban, vegetation, etc.)
_____The site location in a catchment
_____Site size
_____What does the structure plan, comprehensive catchment plan, or neighbourhood plan indicate for the site and adjacent areas

In addition, a site plan should be prepared detailing, but not necessarily limited to, the following items and areal extent.

_____Wetlands
_____Streams including 1^{st} or 2^{nd} order ones
_____Floodplains
_____Riparian buffers
_____Existing vegetation cover
_____Soils
_____Steep slopes in excess of 33% (18^{o})
_____Other natural site features
_____Cultural or archaeological locations

When considering LID, the following questions should be answered to provide a complete picture of the site and process of site design.

Hydrologic Factors (answer Y, N, ?)

_____Does the site drain directly into tidal waters?
_____Does the receiving system have special status, as defined in; the Auckland Regional Policy Statement, District Plan, Regional Plan, Conservation Management Strategy, SSWI, PNA?
_____Are there known downstream flooding problems?
_____Does the site contain a 1^{st} or 2^{nd} order stream?

_____ Are any streams on the site perennial?
_____ Can roof or site generated runoff be reused to reduce the overall volume of stormwater runoff?
_____Do impervious surfaces drain directly to receiving waters?

Any answers that are Y should be accompanied by a description or explanation. Answers that are no reduces concerns that may exist on a given site.

Building Programme (answer Y, N, ?)

_____Does the site have public sewer?
_____Does the site have public water?
_____Can the development reduce the total number of units?
_____Can the type of units be modified (single family to apartment)?
_____Is there flexibility in zoning allowed?
_____Is there flexibility in individual lot requirements?

Lot configuration and design (answer Y, N, ?)

_____Have lots been reduced in size as far as practicable?
_____Have lots been clustered as far as practicable?
_____Have lots been configured to avoid important natural areas?

Impervious surface reduction (answer Y, N, ?)

_____Have road lengths and widths been reduced as far as practicable?
_____Have driveway lengths and widths been reduced as far as practicable?
_____Have parking ratios and parking sizes been reduced as far as practicable?
_____Has potential for shared parking been examined fully?
_____Have cul-de-sacs and turnarounds been designed to minimise imperviousness?
_____Has kerbing been reduced to the extent possible or have kerb cuts been used to reduced flow concentration?

Minimisation of disturbance to site vegetation (answer Y, N, ?)

_____Has maximum total site area, including both soil and vegetation been protected from clearing or other site disturbance?
_____Can disturbance of important natural areas be minimised?
_____Are areas of open space maximised?
_____In terms of individual lots, has maximum lot area, including both soil and vegetation, been protected from clearing or other site disturbance?
_____Do structures correspond to site features such as slope, both in terms of type of structure, placement on lot, elevation, etc.?
_____Have revegetation opportunities been maximised throughout the site?
_____Have revegetation opportunities been maximised in important natural areas?

Mitigation design practices (answer Y, N, ?)

_____Has the stormwater plan been integrated into the overall site design?
_____Has prevention been maximised through LID?
_____Has mitigation been maximised through vegetative and soil based practices?

_____ Can unpreventable impacts be mitigated through conventional stormwater management controls?

Sediment control and stormwater computations are submitted which provide the following information:

_____As a result of a decrease in the total disturbed area, are numbers of sediment ponds minimised as far as practicable, and subsequently their sizes and areal extent also minimised?
_____Total sediment yield from the site during construction has been minimised as far as practicable from the conventional approach as determined by the universal soil loss equation?
_____Could impervious cover be minimised as far as practicable for calculations?
_____Have runoff curve numbers been minimised as far as practicable from conventional to LID?
_____Have total runoff volumes been affected?
_____Has the predevelopment time of concentration for site runoff been maintained as far as practicable?

Runoff Curve Number Discussion

The runoff curve number approach to hydrologic design as detailed in TP 108 "Guidelines for Stormwater Runoff Modelling in the Auckland Region" is critical in determining how much runoff will occur from any given site. By minimising the runoff curve number, runoff will be minimised. Runoff curve numbers are affected by both the soil grouping (A, B, C, D) and the land cover type. Development increases the runoff curve number by changing site conditions and by adding impervious surfaces.

When doing hydrologic design, impervious areas should be measured from aerial photographs (for existing development) or from design plans. Within homogeneous catchments, impervious surfaces can be allowed for by using area-weighted values contained in the runoff curve numbers. Catchments containing significant impervious areas connected directly to a reticulated stormwater system should not be modelled as homogeneous. The impervious connected component will have a more rapid response time than the pervious component of the catchment. In cases where impervious surfaces are directly connected to the receiving system a more realistic representation of the catchment may be obtained by modelling the connected impervious areas and pervious areas as separate sub-catchments. As can be seen in this type of analysis, reduction in total site imperviousness will directly be reflected in downstream stormwater flows.

Many of the LID approaches have the specific aim of reducing the runoff curve number, and keeping it as close to the predevelopment number as possible. This is accomplished by reducing site imperviousness and disturbance in addition to implementation of control measures. These measures can considerably reduce the amount of runoff generated and thus reduce the required mitigation needed.

Clustering and reduction in road widths and driveway lengths can significantly reduce the amount of site imperviousness.

Clustering and reduction in road widths and driveway lengths can significantly reduce the amount of site imperviousness, as the case studies in Chapter 6 will illustrate. Impervious surfaces have a very high runoff curve number (98) and generate a significant amount of runoff. Minimising these areas helps keep the overall site runoff curve number closer to the predevelopment condition.

Runoff curve numbers can also be reduced by revegetation. Open space areas and even portions of individual lots may be revegetated to both reduce the amount of stormwater runoff generated and help mitigate the runoff that is created. Although it will take time for reforested areas to actually become fully established, they will still provide stormwater reduction as they move towards maturity.

LID concepts have the most significant impact on runoff curve numbers. This is one of the main reasons stormwater computations must be considered throughout the entire planning process. Decisions made early in the site planning process have significant effects on the final site runoff curve number and thus on the amount of stormwater generated.

Time of Concentration

The time of concentration relates directly to the peak stormwater flow rate. Many factors affect the time it takes water to move through a site to a point of discharge including the initial amount of water, routing of the water, and the surface that the water passes over (grass, forest, concrete). All of these factors are important considerations in the LID approach.

Stormwater must be routed through the site to avoid flooding roads, houses and other important features. The longer the flow route, the longer the time it takes water to reach the site discharge point(s). Conventional development plans often shorten the water routes through a site with piping and kerb and channel systems. Shortening the route increases the peak discharge. In LID these routes are kept as long as possible attempting to replicate the predevelopment flow paths. A longer flow path will often lower the peak rate of discharge.

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Just as important as the route the water takes is the surface over which it flows. Vegetated surfaces slow water and may also provide some infiltration and water quality benefits. This is especially true during the smaller, more frequent events. The use of vegetated swales and filter strips rather than enclosed pipes or concrete channels may increase the time of concentration by both elongating the route and increasing the resistance of the flow surface.

Runoff curve numbers and time of concentration are the two major factors in determining the peak rate of discharge and the total volume of runoff from a site. The above discussion addresses the ways in which LID approaches can be used to meet stormwater objectives. However, the computations don’t fully reflect the many other benefits, environmental and economic, provided by LID. These benefits are discussed throughout the guidelines and need to be considered in the greater context of regional planning and the effects of development on the catchment and the ecosystem.

Additional Stormwater Controls as Needed

The final step in LID will generally be needed although its importance will hopefully be reduced. In most cases, adverse impacts of land development will still require some form of conventional stormwater management, especially for larger storm events. It is hoped that these “conventional” approaches to stormwater management will be reduced in number and size which will result in less site area taken up and less cost associated with design, construction, and maintenance. Those conventional stormwater management practices include ponds, wetlands, filter systems, and biofiltration. These are detailed in Technical Publication 10 “Stormwater Treatment Devices: Design Guideline Manual” (or an approved revision).

When considering conventional stormwater treatment or management as an overlay to LID, the integration of the practice as a component of site design should be carefully considered. LID is an approach that emphasizes a natural approach to site design. Sediment control and stormwater management treatment devices can come in many shapes and forms but design should consider how the practices are integrated with the overall development approach and with the other stormwater related approaches is important. Conventional sediment control and stormwater treatment devices can be designed to function effectively while, at the same time, have an attractive appearance, and minimise concerns of public safety and maintenance obligation. Construction of a wetlands pond for stormwater treatment could assist in restoration of reclaimed wetlands, minimise public concerns over safety, and have a minimal maintenance obligation. The blending of LID with conventional stormwater management could provide effective downstream resource protection while enhancing property values.

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How to Measure Success

There are several obvious questions that have to be asked when doing LID.

1. What are the goals or expectations?
2. How do you know when design efforts are completed?

Table 5-1
Effectiveness of LID Approaches

Best Management Practice	Objective			
	Runoff Rate Reduction	Runoff Volume Reduction	Runoff Contaminant Reduction	Habitat Protection
Reduced street widths	**	**	**	*
Reduced building setbacks	**	**	**	*
Natural drainage	**	**	**	*
Natural detention	***	*	***	**
Natural landscaping	**	***	***	***
Cluster development	**	***	***	***

Effectiveness Key
*** very effective
** moderately effective
* limited effectiveness

The effectiveness of natural landscaping and cluster development will depend on how well these approaches are integrated into the overall landscape and drainage plan.

At this time LID does not have a performance standard associated with it. You will not get a defined answer or a specific target value that you are shooting for. The ultimate goal is to prevent change to predevelopment hydrology when site development occurs, but that mission cannot be achieved in 95% of the sites being developed. Table 5-1 summarises the general effectiveness of each of the site design approaches discussed in this manual. It indicates that most practices are at least moderately effective at providing two or three environmental benefits. Certain practices, notably natural landscaping and cluster development are at least moderately effective in achieving all four of the desired environmental objectives. However, the table also implies that a site design should incorporate several management practices in an integrated fashion to be highly effective in controlling adverse environmental impacts

LID presents a new approach to site design where so many existing site development requirements are questioned. The realistic goal of LID is to reduce impacts to the degree possible so that structural controls are minimised while still creating desirable communities. As such, the design approach is based upon a simple question for each aspect of site development - "Why". Why do we need footpaths on both sides of a street? Why do we need streets to be as wide as they are? Why do lot sizes have to be a minimum dimension? Why do street locations have to be where they are? These questions go on and on throughout site design, and they will probably require iterations and second guessing to get it right.

The realistic goal of LID is to reduce impacts to the degree possible so that structural controls are minimised while still creating desirable communities.

How do you know when design efforts are completed? When you have gone through the questions outlined in this chapter and completed the checklists, and addressed

Table 5-2
Appropriateness of LID for
Selected Development Types

LID Practice	Development Type: Low Density Residential	Medium Density Residential	Multi-family Residential	Commercial/ Industrial
reduced street widths	***	***	***	**
reduced building setbacks	***	***	**	**
natural drainage	***	**	***	**
natural landscaping	***	**	***	**
cluster develop.	***	***	**	*

Appropriateness
*** Generally appropriate
** Occasionally appropriate
* Generally not appropriate

them to the best of your ability, you have completed the process. If you can sit back and look at your work and feel that you have blended site resources into your development approach, reduced stormwater runoff as much as possible, and delivered the best product that you can, you are finished.

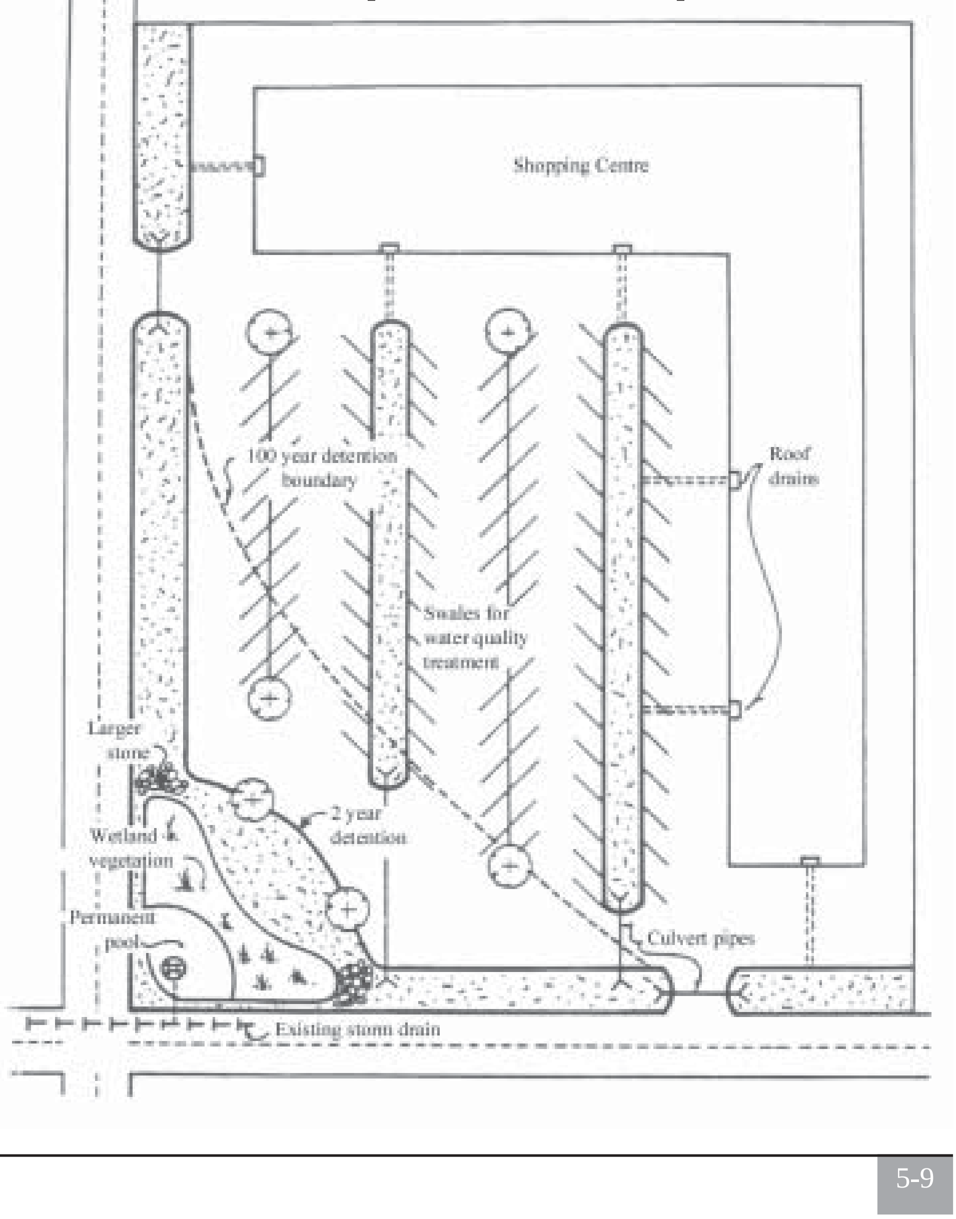
We have to change the way we use land if we are going to have a desirable environment in the future.

What are the goals or expectations? We have to change the way we use land if we are going to have a desirable environment in the future. One tool in that effort is to change how we develop the land. As demonstrated in a number of chapters, our activities have significant impacts on receiving systems in terms of contaminant entry into water and altered catchment hydrology. Our expectations are modest at this time but will certainly increase in the future with hydrologic change to catchments being minimised. Expectations are related to two areas: hydrologic change from predevelopment to postdevelopment should be reduced from a conventional development approach, and site resources as detailed throughout this manual should be protected to the extent possible. Our expectations are to see a reduced downstream impact through LID than would have otherwise occurred in a traditional site design.

Other Types of Development

This manual has devoted itself to residential development as residential development

Figure 5-2
Low Impact Commercial Development



covers the most land area and is the most common form of site development. But commercial, industrial, and even horticultural (especially protected cropping) activities as shown in Table 5-2 can successfully apply LID to reduce their impact on receiving systems. The approach is identical to residential LID in that existing site resources are delineated, site development is integrated into the site, and LID approaches to stormwater treatment are investigated. Not all LID approaches are suited to all development types. For example, site revegetation is most easily done on larger residential lot development, but is less feasible on small commercial development.

Any site being developed can incorporate LID. The preceding example detailed in Figure 5-2 is for a small commercial development and demonstrates several LID design principles. Roof runoff is passed into vegetated swales which then are directed towards a stormwater detention pond having wetlands attributes. The site design promotes water quality treatment in addition to providing control of water quantity peak discharges for the 2 and 100 year storm events. As can be seen, the project does have to provide structural stormwater management control but the work done by the controls is augmented by using the swales for water quality treatment in addition to benefits provided by the wetlands vegetation.

The same issues related to residential site development requirements exist for commercial and industrial development in terms of kerbing, parking requirements, level of imperviousness, or revegetation opportunities. Almost every site can have steps taken to reduce downstream impact from conventional development approaches. The key element that is important is that combinations of approaches should be employed in an integrated fashion to maximise cumulative benefits.

Almost every site can have steps taken to reduce downstream impact from conventional development approaches.

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