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Low Impact Design Versus Conventional Development

Literature Review of Developer-related Costs and Profit Margins

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Low Impact Design Versus Conventional Development: Literature Review of Developer-related Costs and Profit Margins

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1 Executive Summary

This report addresses a literature review of developer related costs and profit for low impact design (LID) versus conventional development approaches. Costs are limited to examination of construction costs. Other economic cost methods include life cycle cost analysis and benefit-cost analysis, which are not contained in this report.

LID is a valuable approach to reduce stormwater and land development impacts and to move further towards sustainable development. Implementation of LID in the Auckland region has progressed at a slow rate for a number of reasons. There are three principal reasons why implementation has lagged.

- Lack of understanding of what LID is and how to accomplish design;
- Lack of support and promotion by a number of territorial authorities; and
- Lack of acceptance by the development community.

The focus of this report is to address one aspect that may contribute to the lack of acceptance by the development community – a perceived misunderstanding the LID increases costs and reduces profit margins. There are a number of developments in New Zealand and internationally that can be used to compare relative costs between conventional versus LID approaches. Documenting the cost information can provide some assurance to developers and others that implementing LID is equivalent or less costly than implementing conventional development, and in many situations reduces construction costs and provide a greater profit margin.

Clearly, the costs depend on an effective, thoughtful design approach but a key outcome is that LID can provide for a more desirable community that incorporates additional amenities and open space, and one that reduces impacts to natural systems generally with no additional construction costs.

Two tables summarise findings contained in this report. Table 1 provides a summary of nine case studies. The percent difference column shows that for all case studies the LID approach was less costly. The primary reason for the reduced cost is that clustering reduces impervious surfaces and amount of earthwork required for site development.

In addition to the cost data, the three Auckland subdivisions also had valuations done to assess profit and risk and the feasibility of each scenario.

The profit and risk allowance expected for a residential subdivision often has a range of 25 to 30 percent of gross realisation before taxation. This return accounts for the general return on capital invested, income for the developer and all associated risks. Risks may include variations in the property market, interest rates, construction costs, as well as resource consent complications as examples.

Table 1

Summary of cost comparisons between conventional and LID site development.

Project	Country	Conventional development costs ($)	LID cost ($)	Cost differential ($)	Percent difference (%)
Heron Point	New Zealand	1,844,000	1,590,000	254,000	14
Palm Heights	New Zealand	7,218,000	5,936,000	1,282,000	18
Wainoni Downs	New Zealand	5,963,000	4,478,000	1,485,000	25
Chapel Run	USA	2,460,200	888,735	1,571,465	64
Buckingham Green	USA	541,400	199,692	341,708	63
Tharp Knoll	USA	561,650	339,715	221,935	39
Pleasant Hill Farm	USA	1,284,100	728,035	556,085	43
Gap Creek	USA	4,620,600	3,942,100	678,500	15
Auburn Hills	USA	2,360,385	1,598,989	761,396	32

Table 2 presents the gross realisation results for the three Auckland sites. These sites were all developed using a conventional approach subsequently, using site development information an LID approach was used to determine the costs and profit margins and whether there would be a more desirable outcome using an LID approach.

Table 2

Gross realisation of three Auckland sites for conventional development versus an LID approach.

Project	Conventional development valuation (%)	LID development valuation (%)
Heron Point	39	38
Palm Heights	26	18
Wainoni Downs	15	23

An important aspect in encouraging the uptake of an LID approach is to avoid adverse impacts on the profitability or the practicality of the development. From an economic perspective, only one of the three LID designs had a less desirable outcome for a developer. That case study, Palm Heights, had significantly smaller lots to protect watercourses and it was anticipated that there would be less demand for those smaller sites in a greenfield area. On the other hand the Wainoni Downs subdivision had an improved outcome using an LID approach.

Implementation of LID is an important step in the effort to build more sustainable and desirable communities. There are increasing data becoming available on the costs of LID versus conventional development and most of the data indicates that LID approach is less costly than conventional development and can be highly competitive in the marketplace.

Introduction

"Low impact design" is a design approach for site development that protects and incorporates natural site features into erosion and sediment control and stormwater management plans (Shaver 2004).

2.1 Purpose

The Auckland Regional Council (ARC) has promoted low impact design (LID) as an approach to reduce adverse impacts related to stormwater run-off for a number of years. The concept is fairly well understood in terms of stormwater treatment devices or practices such as rain gardens, water tanks and biofiltration practices but other essential concepts such as clustering, reducing site imperviousness and protecting or enhancing natural site features are less understood.

In addition to the practices and site development approaches, there is poor understanding of the associated costs of LID and how those costs compare to conventional development costs. The purpose of this report is to provide documentation, based on case studies, of anticipated costs for conventional and LID development, along with some discussion of profit margin.

While the report's purpose is to present cost information, it is important to provide a very brief discussion of what comprises LID.

2.2 LID approach

LID approaches reflect a different philosophy towards site design that integrates stormwater management into the core of site design, as opposed to consideration as an afterthought to site design, as often occurs with a conventional approach. These LID approaches can include a combination of strategies, planning and practical implementation This report cannot include all potential variations; it presents some of the more commonly recognized LID elements.

An LID approach treats stormwater run-off as a "resource" rather than a "waste-product" of development. As such, there are a number of key site design components to consider:

- Reducing site disturbance;
- Reducing impervious surfaces;
- Constructing biofiltration practices (rain gardens, swales, etc.);
- Using infiltration practices where they are suitable;
- Water reuse;
- Creating or enhancing natural areas; and

- Clustering development (Shaver 2004).

These individual elements are discussed briefly in the following subsections.

2.2.1 Reducing site disturbance

Many sites have existing resources that, in addition to other values, have soil retention and stormwater management benefits. These natural systems include forested areas, wetlands and other areas of natural value.

Forested areas provide for rainfall interception by the leaf canopy. In addition, an organic forest litter develops on the forest floor which acts like a sponge to capture the water and prevent overland flow. Trees provide for uptake and storage of nutrients. They also moderate temperatures during the summer and provide wildlife habitat, thus providing other environmental benefits.

Wetlands are valuable resources and provide numerous benefits including flood control, low stream flow augmentation, erosion control, water quality and habitat. They are very productive ecosystems whose maintenance have significant water quantity and quality benefits. Where they exist on a development site, they could become an important element in site design.

From a construction standpoint, leaving areas in natural ground cover can have a significant benefit by reducing downstream sediment delivery. Sediment yield from disturbed soils can be 2000 times greater than yields from forested areas (Shaver 2004). Leaving site areas undisturbed is an important component of a LID approach.

2.2.2 Reducing impervious surfaces

Impervious surfaces (e.g., roads, roofs, footpaths) prevent the passage of water through their surface into the ground. Water must then be transported across the surface to a point of discharge. Residential subdivision designs can reduce the width of roadways, or design the roadways to limit the total length needed to service individual properties. In addition, roof down drains could be provided with splash blocks to discharge water across grass and away from impervious surfaces, rather than connecting directly to streets or reticulation systems (as is common in conventional development). Diverting water across pervious areas will allow a greater amount of water to infiltrate into the ground.

2.2.3 Constructing biofiltration practices

The use of vegetative swales, buffer strips and rain gardens can provide a significant water quality benefit in addition to reducing the total volume of stormwater run-off . The primary processes involved in their performance are filtering of contaminants contained in stormwater run-off, evapotranspiration and infiltration of run-off into the ground.

For example, Kerb cuts or openings can be placed in the kerb to allow water to pass off the paved surface into a biofiltration practice (Figure 1). This practice allows both objectives (traffic control and stormwater management) to be attained.

Figure 1
Example of kerb cuts allowing stormwater to sheet flow across a buffer strip.

2.2.4 Using infiltration practices where they are suitable

Infiltration practices reduce total volumes of stormwater run-off by taking surface run-off and infiltrating it into the ground. The most common infiltration practices in the Auckland region are trenches, dry wells (for roof run-off) and modular paving. Infiltration practices are important in the southern districts of the region due to the presence of peat soils which require saturation to prevent settling.

2.2.5 Water reuse

Using stormwater generated from roof areas or even from impervious surfaces for domestic or industrial purposes can reduce the total volume of stormwater discharged, as water reused is separated from catchment stormwater delivery. Water reuse is potentially a valuable tool in reducing stormwater run-off volumes and possesses other beneficial effects such as reduced use of potable water for non-potable needs (eg, Figure 2).

2.2.6 Creating natural areas

In many site development situations, the pre-development condition may be pasture or other highly modified land use. Re-establishment of native bush as riparian cover, steep slope protection or general site revegetation as open space have significant stormwater management benefits for both water quantity and water quality. The area, if well-designed and constructed, can become an attractive amenity to a community and enhance the value of the properties.

Figure 2
Water reuse at Waitakere Hospital.

2.2.7 Clustering development

How a site is developed and to what degree the entire site must be utilized can have a significant impact on site sediment and stormwater run-off. Conventional land development encourages using the entire site for a "cookie cutter" form of development, while LID approaches can provide significant sediment reduction during construction and provides post-construction stormwater benefits by reducing site disturbance (Figure 3).

Cluster development encourages smaller lots on a portion of a site, allowing the same or even increased site density, leaving more site area in open space and disturbing less of the natural ground cover. Clustering encourages compact residential neighbourhoods, with smaller lots, as are found in traditional villages and small towns. Cluster development can provide for protection of natural areas within the site, while at the same time reducing total site imperviousness by reducing the areal extent of roads.

Figure 3
House clustering schematic for a residential subdivision

Economic Analysis

2.3 Introduction

The purpose of this report is to present case studies that provide economic information on LID. It is a simplistic approach to a complicated topic, but can help developers, territorial authority staff and the general public understand the costs associated with conventional development and LID.

There are three common methods to consider the economics of LID (North Carolina State University undated). The one adopted in this report is cost comparisons using construction costs. It does not include the benefits of improved environmental outcomes as it is focused primarily on benefits that a developer may realise. As such, it is an incomplete assessment and has a narrow focus on developer impacts. As such, it underestimates the full value of LID.

Other methods can include the following:

- Life cycle cost analysis, which considers planning, design, installation, operation and maintenance and decommissioning. This is a more complete analysis than is the cost comparison analysis but it still can disregard economic benefits of implementing LID and ignores differences in effectiveness.
- Benefit-cost analysis considers the full range of costs and benefits. This approach is not often undertaken due to increased data needs and difficulty in quantifying benefits.

It is important to recognise that the cost data provided in this report is limited to consideration of comparative costs.

Every site has different costs and benefits based on site conditions and local requirements. The costs presented here are for typical sites from a number of different locations and represent what reasonable costs are for conventional and LID development. There is more information available for other sites but the general trend is the same. The sites selected had more information available which ensures transparency. There was no effort or intent to prejudice the data and exclude projects having a less favourable outcome from an LID perspective.

3 Case Studies

3.1 Introduction

The approach taken in a discussion of LID cost information versus conventional development was to use data developed from the Auckland region and additionally to provide information from international sources that provide relative cost differences in consideration of conventional development and LID development. As such, the cost levels are not as important as the relative differences between costs.

The information presented in this section is a summary of detailed information that has been generated on specific projects. The Appendix provides a discussion of each of the projects with greater detail.

3.2 Project identification

Three projects from the Auckland region are reviewed, with all three projects having an estimation of a developers allowance for profit and risk to determine the Gross Realisation from the projects. Six projects from the USA are also reviewed.

The projects include the following:

Local projects

- Heron Point
- Palm Heights
- Wainoni Downs.

International projects (all USA)

- Chapel Run
- Buckingham Green
- Tharp Knoll
- Pleasant Hill Farm
- Gap Creek
- Auburn Hills.

3.3 Summary of comparisons

Table 3 provides a summary of costs between conventional and LID approaches for the subdivisions mentioned above. The percent difference column provides the savings provided by LID approaches versus conventional development costs.

Table 3

Summary of cost comparisons between conventional and LID site development.

Project	Country	Conventional development costs ($)	LID cost ($)	Cost differential ($)	Percent difference (%)
Heron Point	New Zealand	1,844,000	1,590,000	254,000	14
Palm Heights	New Zealand	7,218,000	5,936,000	1,282,000	18
Wainoni Downs	New Zealand	5,963,000	4,478,000	1,485,000	25
Chapel Run	USA	2,460,200	888,735	1,571,465	64
Buckingham Green	USA	541,400	199,692	341,708	63
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Pleasant Hill Farm	USA	1,284,100	728,035	556,085	43
Gap Creek	USA	4,620,600	3,942,100	678,500	15
Auburn Hills	USA	2,360,385	1,598,989	761,396	32

Sources: Beca Valuations 2000; Conservation Research Institute 2005; Delaware Department of Natural Resources and Environmental Control 1997; USEPA 2007.

3.4 Valuation of Auckland sites

In addition to the cost comparisons, the three Auckland subdivisions also had an estimation of a developers allowance for profit and risk to assess the feasibility of each scenario. A subdivision model was used to derive an estimate of developer risk.

The profit and risk allowance expected for a residential subdivision often has a range of 25 percent to 30 percent of Gross Realisation before taxation. This return accounts for the general return on capital invested, income for the developer and all associated risks. Risks may include variations in the property market, variations in interest rates, variations in construction costs and resource consent complications among others.

Table 4 presents the Gross Realisation results for the three Auckland sites.

Table 4

Gross realisation of three Auckland sites for conventional development versus an LID approach.

Project	Conventional development valuation (%)	LID development valuation (%)
Heron Point	39	38
Palm Heights	26	18
Wainoni Downs	15	23

Source: Beca Valuations Ltd 2000.

One goal of LID is to avoid a negative impact on the profitability or the practicality of the project. From a financial economic perspective, only one of the three LID designs had a significantly less desirable outcome for a developer. That case study, Palm Heights, had significantly smaller lots with LID to protect watercourses, and it was anticipated that there would be less demand for those smaller sites in a greenfield area. Conversely Wainoni Downs had significantly greater Gross Realisation.

The three case studies are discussed in Appendix 1.

4 Discussion

The local examples and review of literature demonstrate that the use of LID for subdivision development can save money and, if done well, can increase profit margins.

There are a number of conclusions that can be made from the information reviewed in this report, as well as broader consideration of LID versus conventional approach (eg, Shaver 2004).

- Urban sprawl increases public infrastructure costs.
- At the site level, significant cost savings can be achieved from clustering, which includes costs for clearing and earthworks, and for stormwater and transportation infrastructure as well as services.
- Natural landscaping is cheaper than lawn grasses to maintain.
- Better site design can reduce paved areas and associated costs.
- Swale drainage systems are cheaper to install than pipe systems.
- Conventional stormwater quantity and quality management costs can be reduced if an LID approach is used.
- The use of multiple approaches such as clustering and impervious surface reduction in conjunction with LID practices such as swales and rain gardens can provide greater benefits than considering any one of the items in isolation.

By looking at the case study results from an economic perspective, a number of points can be made.

- The data contradict any notion that LID is always more expensive than conventional development. In fact, the case studies indicate a significant reduction in development costs may result when compared to conventional techniques.
- In general, reducing the extent of land disturbance will reduce construction costs. Clustering and minimal site disturbance can contribute significantly to reduce infrastructure costs, especially for stormwater management.

Benefits to developers can include the following:

- Increased number of buildable lots due to smaller lot sizes and reduction in lot area devoted to conventional stormwater treatment.
- Less spent on infrastructure by replacing kerb and channel drainage with roadside swales.
- Increased property values have been demonstrated in the literature.
- Initial savings from LID are usually accomplished through less conventional stormwater infrastructure, less paving and lower site preparation costs.

The cost information demonstrates that LID should be given more consideration across the spectrum of development forms. With that said, cost information is only one reason as to why LID should be more aggressively promoted and implemented. There are multiple environmental and social reasons for implementing LID. The existing approach to land use has significant impacts on aquatic resources and community health. There are a number of reasons why LID should be promoted but a key element in its acceptance is that it is cost effective from a developer context.

It is important to recognise that LID is not an “all or nothing” approach to site development. There are a range of approaches, practices, and levels of implementation that can be considered on a case-by-case basis.

5 References

BECA VALUATIONS LTD, 2000. *Low Impact Development Subdivision Case Studies*. Prepared for the Auckland Regional Council.

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NORTH CAROLINA STATE UNIVERSITY, undated. *Low Impact Development - an economic fact sheet*, North Carolina State University Cooperative Extension.

SHAVER, E., 2004. *Low Impact Design Manual for the Auckland Region*. Auckland Regional Council Technical Publication No. 124.

USEPA, 2007. *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices.* Nonpoint Source Control Branch (4503T), Washington DC.

7 Appendix 1: Case Study Overview

The following case studies provide more detailed information on projects in Section 4 (Beca Valuations 2000; Conservation Research Institute 2005; Delaware Department of Natural Resources and Environmental Control 1997; USEPA 2007). Where available, site plans are provided to visually show the differences between conventional and LID development. In addition to basic site information, more detailed cost information are provided along with stormwater calculations (also where available) that provide a comparison of conventional versus LID approaches. Several international case studies lacked stormwater run-off calculations so that these calculations were not able to be included.

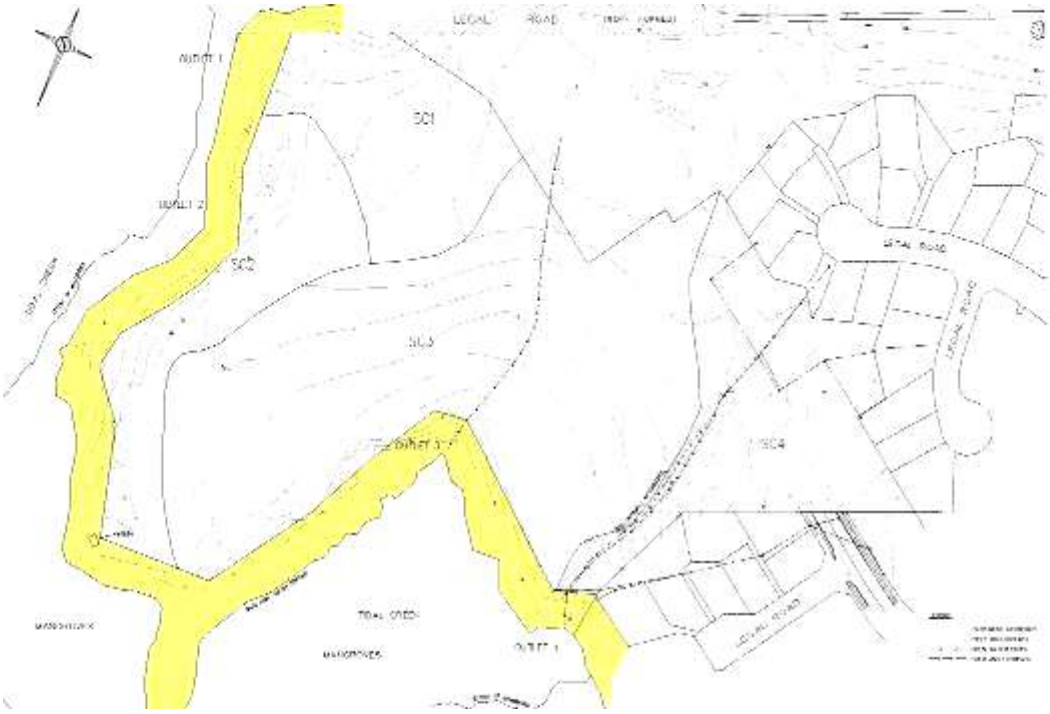
The information includes the following:

- Pre-development site conditions;
- Conventional development approach;
- LID site development approach;
- Stormwater calculations (where available);
- Detailed construction cost estimates for both conventional and LID development; and
- Site Gross Realisation on Auckland projects.

7.1 Case study 1: Heron Point

Heron Point, as shown in its pre-development condition in Figure 4, is located adjacent to a harbour environment and has an areal extent of 7.4 ha. The pre-development land use is pasture with some minor stands of trees located around the perimeter.

Figure 4
Heron Point pre-development site plan.



The conventional development proposed 100 lots with an average lot size of 760 m^2. Stormwater quality treatment used a stormwater pond located adjacent to the harbour. The reserve area is one hectare and earthworks are proposed for 6.9 hectares with a total earthworks volume of 50,000 m^3. Site imperviousness is 70 percent.

Figure 5 shows site development using a conventional development approach.

The LID subdivision proposes 104 lots (four more than the conventional development) with an average lot size of 650 m^2. Stormwater treatment is provided by a swale for the main access road and smaller treatment ponds in two other locations. The reserve area has been increased to 2.34 hectares and earthworks are proposed for 5.9 hectares with a total earthworks volume of 30,000 m^3. Site imperviousness is 56 percent.

Figure 6 shows site development from an LID perspective.

Figure 5
Heron Point conventional development site plan

Figure 6
Heron Point LID development site plan

Stormwater run-off volumes

Table 5 provides information on stormwater run-off from an annual context for a conventional versus LID design approach.

Table 5
Heron Point case study: annual stormwater run-off volumes and percentages related to pre-development conditions.

Land use	Annual run-off volume (m^3)	Percentage increase from pre-development condition (%)
Pre-development	11,311	-
Conventional development	44,941	397
LID development	37,737	334 (16% less than conventional development)

Cost estimates

Table 6 provides a detailed breakdown of costs related to a conventional subdivision and an LID approach.

Table 6
Heron Point case study: conventional development versus LID development – schedule of costs.

Item	Standard subdivision ($)	LID subdivision ($)
Clearing and earthworks	347,000	293,000
Pavement construction	447,000	333,000
Sanitary sewers	196,000	242,000
Stormwater drainage system	394,000	311,000
Water reticulation	126,000	123,000
Trenching/ducting/cabling	46,000	45,000
Retaining wall	0	57,000
Dayworks and general	288,000	186,000
Total	**1,844,000**	**1,590,000**
The "dayworks and general" category are those costs that involve changes from the original proposal. It can include unexpected costs and changes in hourly rates or can be due to additional work needs.		

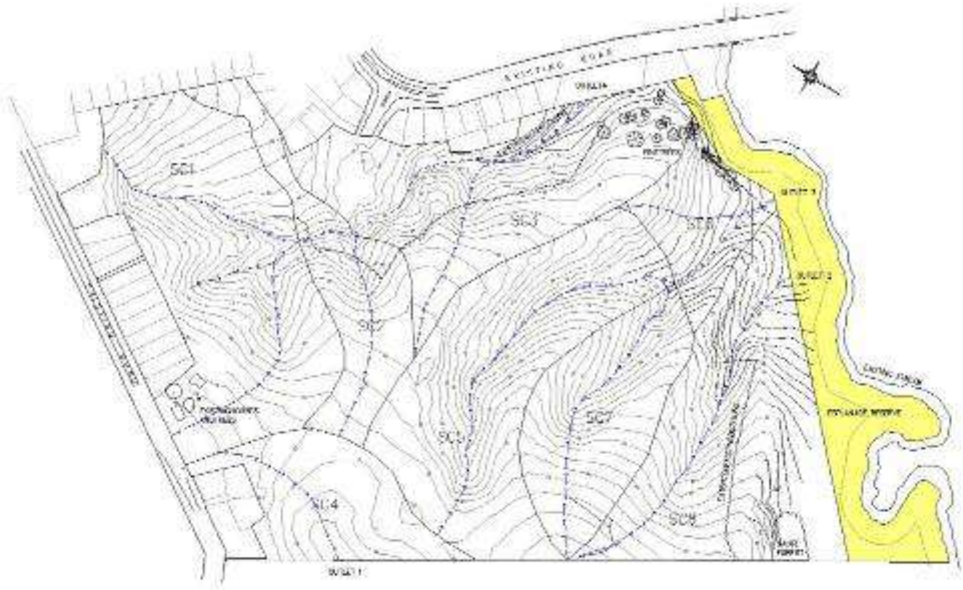
Site gross realisation

The developer's profit for the actual subdivision is expected to be $2,800,000. For the LID subdivision it is expected to be $2,500,000. Analysis of the conventional subdivision indicates a developer would expect an allowance of gross realisation for profit and risk of 39 percent and the LID subdivision an allowance of 38 percent. From a financial perspective both scenarios appear equally viable.

7.2 Case study 2: Palm Heights

Palm Heights, as shown in its pre-development condition in Figure 7, is located mid-catchment that drains through a stream system to a harbour. The site is 27.7 hectares in size, has a pre-development land use of pasture and has a series of gullies that drain the site.

Figure 7
Palm Heights pre-development site plan.



The conventional development proposed 297 lots with an average lot size of 600 m^2. The reserve area is 3.75 hectares and earthworks are proposed for 23.7 hectares with a total earthworks volume of 330,000 m^3. Site imperviousness is 54 percent.

Figure 8 shows site development using a conventional development approach.

The LID subdivision proposes 275 lots with an average lot size of 511 m^2. Stormwater treatment is provided by a swale for the main access road and smaller treatment ponds in two other locations. The reserve area has been increased to 8.61 hectares and earthworks are proposed for 18.8 hectares with a total earthworks volume of 235,000 m^3. Site imperviousness is 39 percent.

Figure 9 shows site development from an LID perspective.

Figure 8
Palm Heights conventional development site plan.

Figure 9
Palm Heights low impact design development site plan.

Stormwater run-off volumes

Table 7 provides information on stormwater run-off from an annual context for a conventional versus an LID approach.

Table 7
Palm Heights case study: annual stormwater run-off volumes and percentages related to pre-development conditions.

Land use	Annual run-off volume (m^3)	Percentage increase from pre-development condition (%)
Pre-development	77,202	-
Conventional development	209,898	270
LID development	170,119	220 (19% less than conventional development)

Cost estimates

Table 8 provides a detailed breakdown of costs related to a conventional subdivision and an LID approach.

Table 8
Palm Heights case study: conventional development versus LID development – schedule of costs.

Item	Standard subdivision ($)	LID subdivision ($)
Clearing and earthworks	1,800,000	1,719,000
Pavement construction	1,362,000	1,134,000
Sanitary sewers	850,000	778,000
Stormwater drainage system	1,178,000	1,050,000
Water reticulation	492,000	455,000
Trenching/ducting/cabling	338,000	330,000
Concrete works	1,036,000	574,000
Dayworks and general	162,000	160,000
Total	**7,218,000**	**5,536,000**
The "dayworks and general" category costs are those costs that involve changes from the original proposal. It can include unexpected costs and changes in hourly rates or can be due to additional work needs.		

Site gross realisation

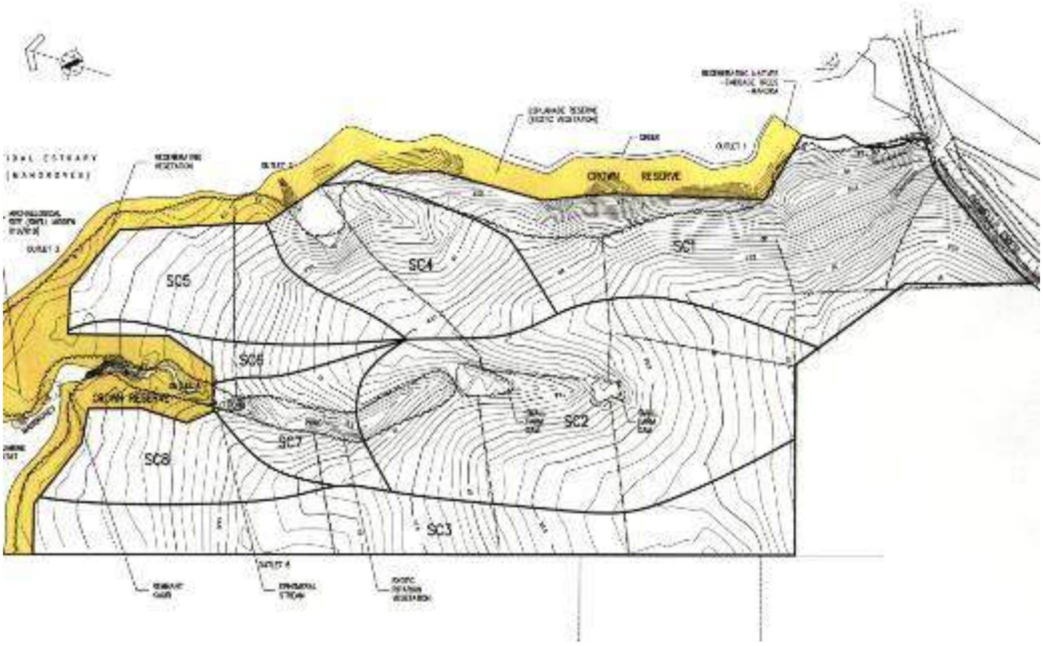
The developer's profit for the actual subdivision is expected to be $8,420,000. For the LID subdivision it is expected to be $4,760,000. Analysis of the conventional subdivision indicates a developer would expect an allowance of gross realisation for profit and risk of 26 percent and the LID subdivision an allowance of 18 percent. From a financial perspective the LID scenario does not appear to offer sufficient return to investment.

In this case the limited demand for smaller site areas was reflected in the reduced profit margin for the LID approach.

7.3 Case study 3: Wainoni Downs

Wainoni Downs, as shown in its pre-development condition in Figure 10, has a small stream passing through the site and is adjacent to a tidal estuary.

Figure 10
Wainoni Downs pre-development site plan.



The site is 14.2 hectares in size, has a pre-development land use of pasture and has a steep drop off to the estuary.

The conventional development proposed 128 lots with an average lot size of 766 m^2. The reserve area is 1.09 hectares and earthworks are proposed for 9.6 hectares with a total earthworks volume of 62,000 m^3. Site imperviousness is 69 percent.

The LID subdivision proposes 138 lots with an average lot size of 651 m^2. Stormwater treatment is provided by two offline treatment wetlands. The reserve area has been increased to 2.34 hectares and earthworks are proposed for 7.6 hectares with a total earthworks volume of 53,000 m^3. Site imperviousness is 51 percent.

Figure 12 shows site development from an LID perspective, while Figure 11 shows site development using a conventional development approach.

Figure 11
Wainoni Downs conventional development site plan.

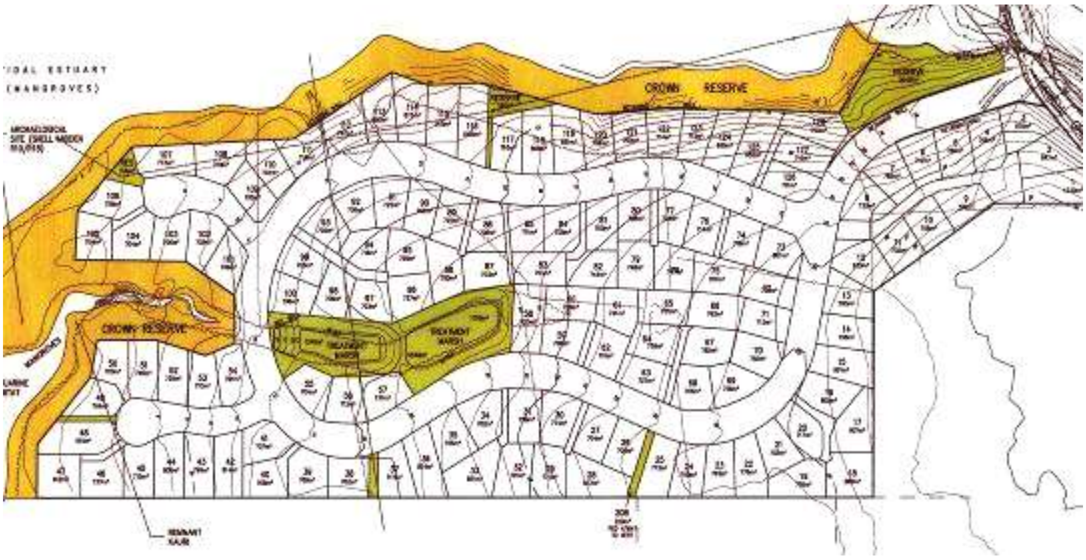


Figure 12
Wainoni Downs LID development site plan.

Stormwater run-off volumes

Table 9 provides information on stormwater run-off from an annual context for a conventional versus an LID approach.

Table 9

Wainoni Downs case study: annual stormwater run-off volumes and percentages related to pre-development conditions.

Land use	Annual run-off volume (m^3)	Percentage increase from pre-development condition (%)
Pre-development	31,449	-
Conventional development	99,160	315
LID development	81,945	260 (17% less than conventional development)

Cost estimates

Table 10 provides a detailed breakdown of costs related to a conventional subdivision and an LID approach.

Table 10

Wainoni Downs case study: conventional development versus LID development – schedule of costs.

Item	Standard subdivision ($)	LID subdivision ($)
Clearing and earthworks	1,425,000	805,000
Pavement construction	1,390,000	1,111,000
Sanitary sewers	500,000	498,000
Stormwater drainage system	855,000	861,000
Water reticulation	210,000	220,000
Trenching/ducting/cabling	338,000	330,000
Concrete works	1,123,000	1,123,000
Dayworks and general	460,000	60,000
Total	**5,963,000**	**4,478,000**
The "dayworks and general" category costs are those costs that involve changes from the original proposal. It can include unexpected costs and changes in hourly rates or can be due to additional work needs.		

Site gross realisation

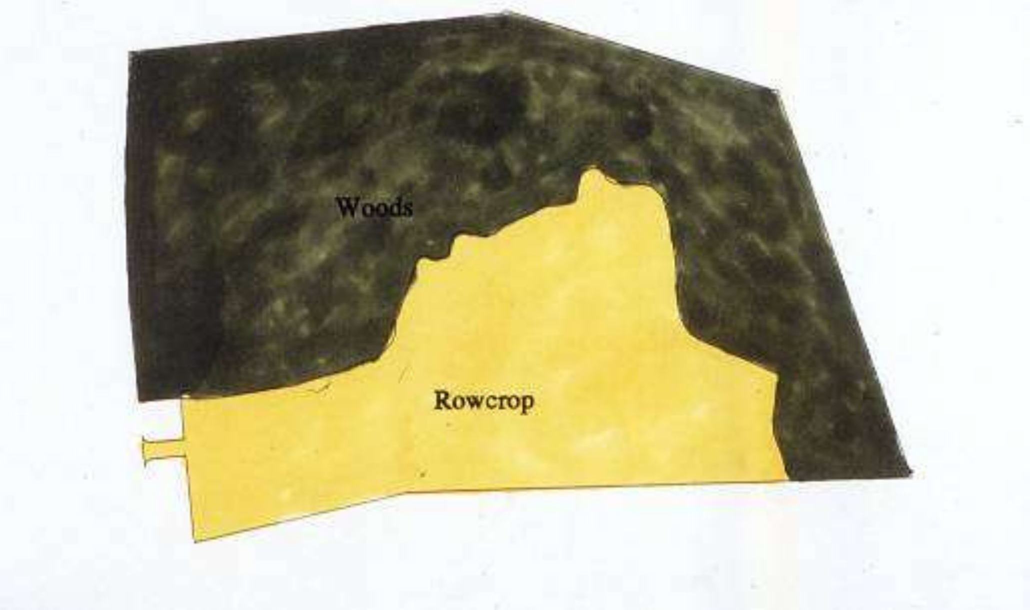
The developer's profit for the conventional subdivision is expected to be $2,640,000. For the LID subdivision it is expected to be $3,960,000. Analysis of the conventional subdivision indicates a developer would expect an allowance of gross realisation for profit and risk of 15 percent and the LID subdivision an allowance of 23 percent. From a financial perspective the LID scenario appears to be a far more attractive scenario.

The reduction in average lot size provides lots that are comparable to lot sizes in other adjacent subdivisions.

7.4 Case study 4: Chapel Run

The Chapel Run case study is in the State of Delaware in the UnitedStates. Chapel Run, as shown in its pre-development condition in Figure 13, has a site area of 40 hectares, has a pre-development land use of pasture and bush and drains into streams that drain to a tidal estuary.

Figure 13
Chapel Run pre-development site plan.



The conventional development proposed 142 lots with an average lot size of 2,000 m^2. There is no reserve area on the site Earthworks and total earthworks volumes were not calculated independently. Site imperviousness is 29 percent.

Figure 14 shows site development using a conventional development approach.

The LID subdivision also proposes 142 lots with an average lot size of 1000 m^2. Stormwater treatment is provided by swales and infiltration practices. The community open space is 50 percent or 20 hectares with a commensurate reduction in earthworks area and volume. Site imperviousness is 15 percent.

Figure 15 shows site development from an LID perspective

Figure 14
Conventional subdivision with blue areas showing stormwater management ponds.

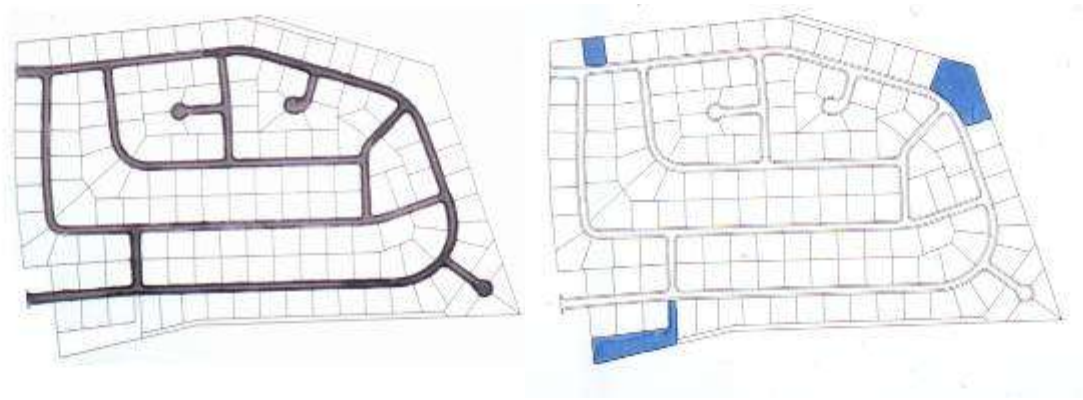
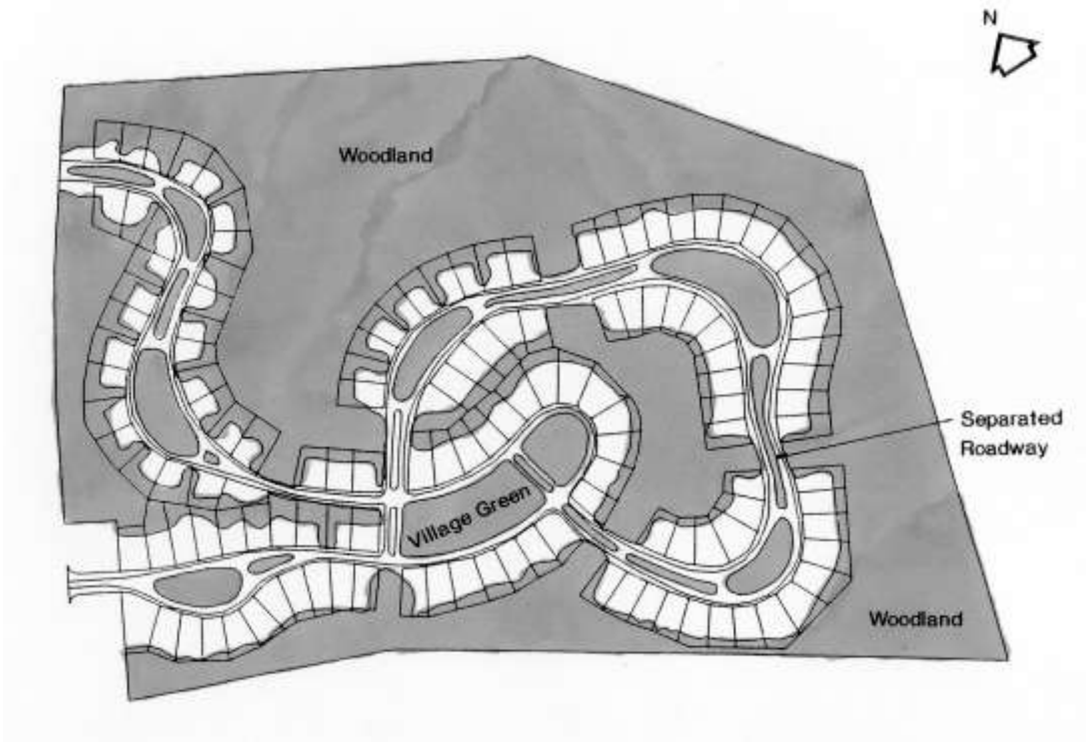


Figure 15
Chapel run LID development site plan.



Stormwater run-off volumes

Table 11 provides information on stormwater run-off from an annual context for a conventional versus LID approach.

Table 11

Chapel Run case study: annual stormwater run-off volumes and percentages related to pre-development conditions.

Land use	Annual run-off volume (m^3)	Percentage increase from pre-development condition (%)
Pre-development	18,761	-
Conventional development	249,515	1300
LID development	67,397	359 (73% less than conventional development)

The stormwater approach used infiltration practices in conjunction with vegetated swales such that the post-development run-off peaks and volumes did not exceed pre-development peaks and volumes.

Cost estimates

Table 12 provides a detailed breakdown of costs related to a conventional subdivision and an LID approach. The cost categories are different from the first three case studies due to the difference in data availability. The total costs are comparable from a relative context.

Table 12

Chapel Run case study: conventional development versus LID development – schedule of costs.

Item	Standard subdivision ($)	LID subdivision ($)
Clearing and earthworks	Not calculated	Not calculated
Pavement construction	2,008,200	663,000
Sanitary sewers	Individual site wastewater	Individual site wastewater
Stormwater drainage system	400,000	164,000
Water reticulation	Individual wells	Individual wells
Trenching/ducting/cabling	Not calculated	Not calculated
Concrete works	52,000	13,000
Dayworks and general·	Not calculated	Not calculated
Reforestation	0	36,855
Total	**2,460,200**	**888,735**
The "dayworks and general" category costs are those costs that involve changes from the original proposal. It can include unexpected costs and changes in hourly rates or can be due to additional work needs.		

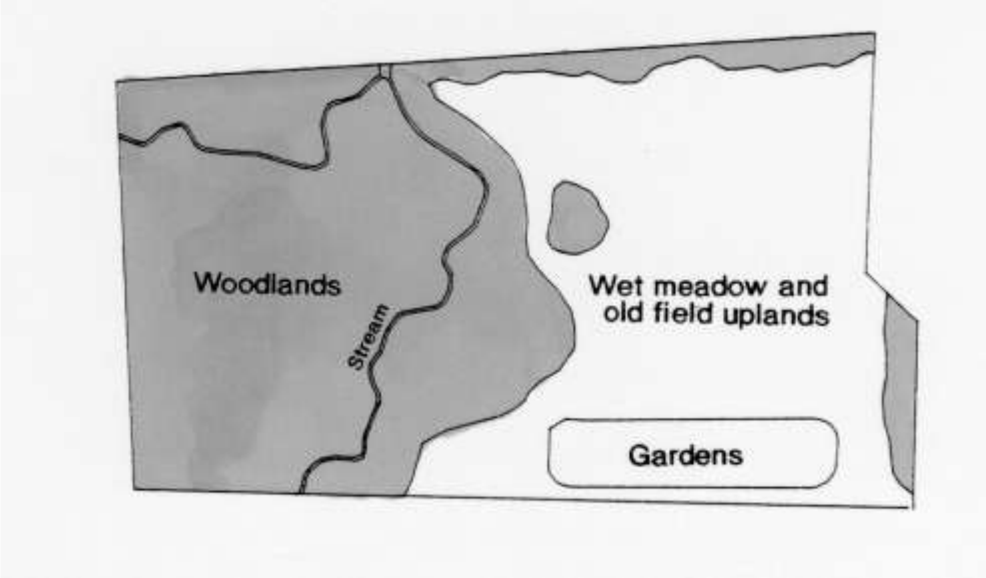
Site gross realisation

A site gross realisation was not done for this project.

7.5 Case study 5: Buckingham Green

The Buckingham Green case study is in the State of Delaware in the UnitedStates. Buckingham Green, as shown in its pre-development condition in Figure 16, has a site area of 7.7 hectares, has a pre-development land use of mixed bush, pasture and recovering bush and drains into streams that subsequently drain to a tidal estuary.

Figure 16
Buckingham Green pre-development site plan.



The conventional development proposed 55 lots with an average lot size of 600 m^2. There is a reserve area on the site of 1.6 hectares. Earthworks and total earthworks volumes were not calculated independently. Site imperviousness is 23 percent.

Figure 17 shows site development using a conventional development approach.

The LID subdivision also proposes 55 lots with clusters of attached housing. Stormwater treatment is provided by swales and infiltration practices. The community open space is 52 percent or four hectares with a commensurate reduction in earthworks area and volume. Site imperviousness is 21 percent.

Figure 18 shows site development from an LID perspective.

Figure 17
Buckingham Green conventional development site plan.

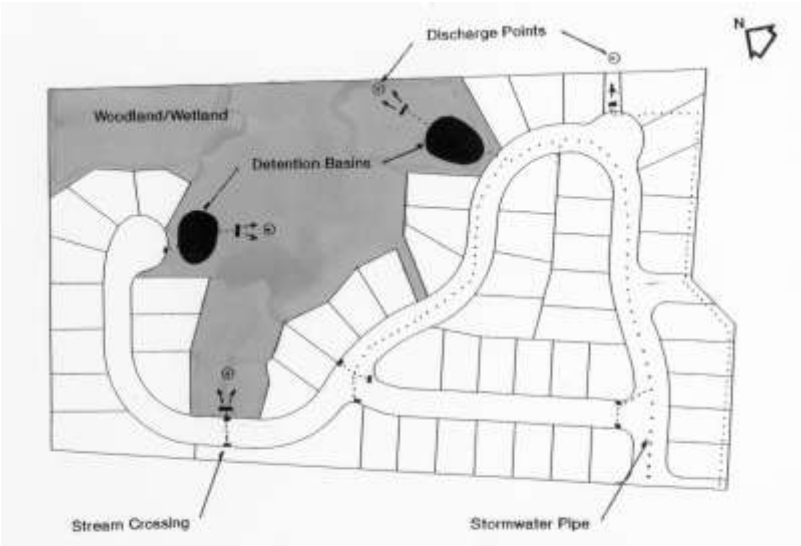
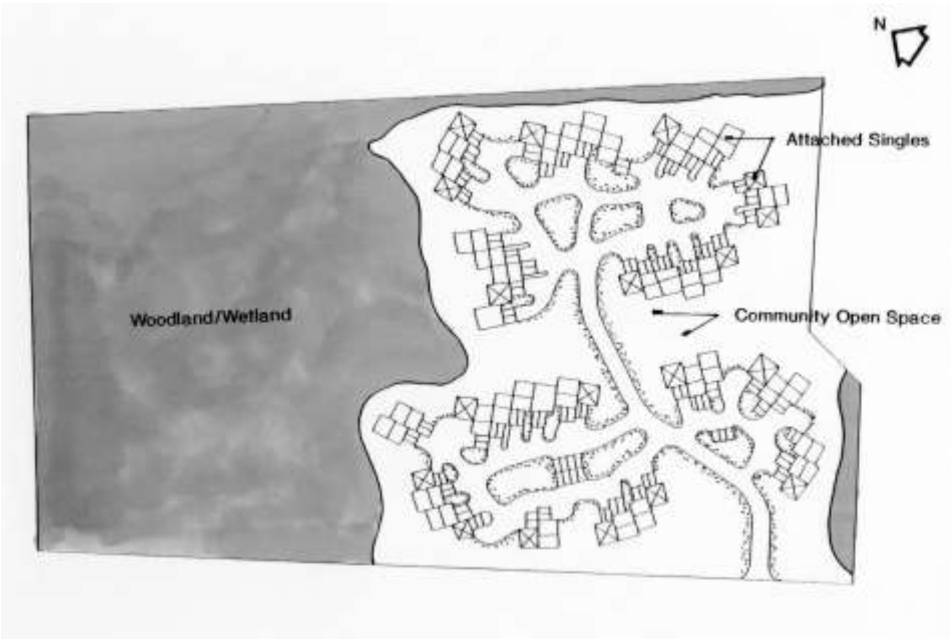


Figure 18
Buckingham Green LID development site plan.



Stormwater run-off volumes

Table 13 provides information on stormwater run-off from an annual context for a conventional versus an LID approach.

Table 13

Buckingham Green case study: annual stormwater run-off volumes and percentages related to pre-development conditions.

Land use	Annual run-off volume (m^3)	Percentage increase from pre-development condition (%)
Pre-development	1206	-
Conventional development	19,276	1598
LID development	18,043	1496 (7% less than conventional development)

The stormwater approach used revegetation, infiltration and vegetated swales such that the post-development run-off peaks did not exceed pre-development peaks and volumes.

Cost estimates

Table 14 provides a detailed breakdown of costs related to a conventional subdivision and an LID approach. The cost categories are different from the first three case studies due to the difference in data availability. The total costs are comparable from a relative context.

Table 14

Buckingham Green case study: conventional development versus LID development – schedule of prices.

Item	Standard subdivision ($)	LID subdivision ($)
Clearing and earthworks	Not calculated	Not calculated
Pavement construction	405,200	178,500
Sanitary sewers	Not calculated	Not calculated
Stormwater drainage system	87,000	15,100
Water reticulation	Not calculated	Not calculated
Trenching/ducting/cabling	Not calculated	Not calculated
Concrete works	49,400	0
Dayworks and general	Not calculated	Not calculated
Reforestation	0	6092
Total	**541,400**	**199,692**
The "dayworks and general" category costs are those costs that involve changes from the original proposal. It can include unexpected costs and changes in hourly rates or can be due to additional work needs.		

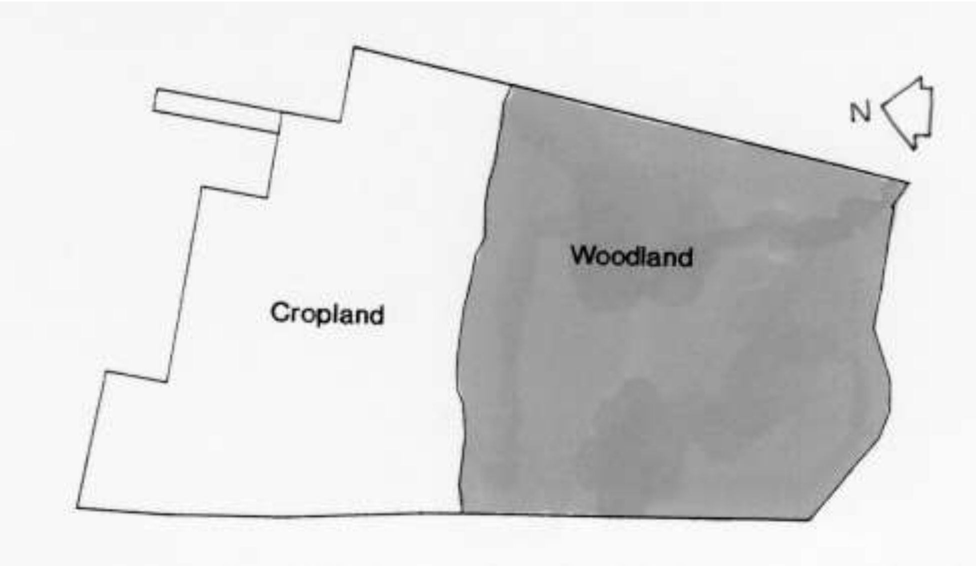
Site gross realisation

A site gross realisation was not done for this project.

7.6 Case study 6: Tharpe Knoll

The Tharpe Knoll case study is in the State of Delaware in the United States. Tharpe Knoll, as shown in its pre-development condition in Figure 19, has a site area of 13.4 hectares, has a pre-development land use of horticultural land and bush and drains into streams that drain to a tidal estuary.

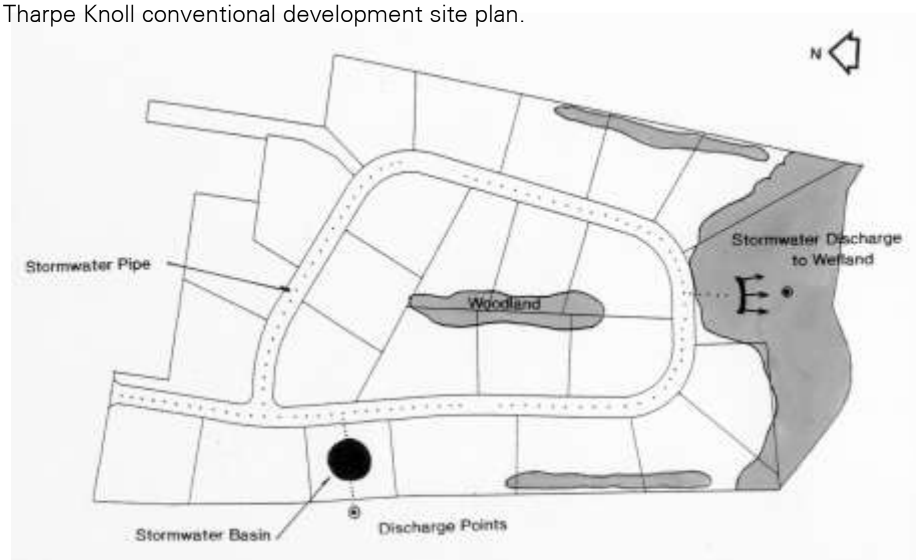
Figure 19
Tharpe Knoll pre-development site plan.



The conventional development proposed 23 lots with an average lot size of 4000 m^2. There is a reserve area on the site of 1.5 hectares. Earthworks and total earthworks volumes were not calculated independently. Site imperviousness is 12.6 percent.

Figure 20 shows site development using a conventional development approach.

Figure 20
Tharpe Knoll conventional development site plan.



The LID subdivision also proposes 23 lots with a cluster approach to housing where each lot is 2000 m^2. Stormwater treatment is provided by swales and revegetation practices. The community open space is 50 percent or 6.7 hectares with a commensurate reduction in earthworks area and volume. Site imperviousness is 7.4 percent.

Figure 21 shows site development from an LID perspective.

Figure 21
Tharpe Knoll LID site development plan.

Stormwater run-off volumes

Table 15 provides information on stormwater run-off from an annual context for a conventional versus LID approach.

Table 15
Tharpe Knoll case study: annual stormwater run-off volumes and percentages related to pre-development conditions.

Land use	Annual run-off volume (m^3)	Percentage increase from pre-development condition (%)
Pre-development	5,180	-
Conventional development	22,196	428
LID development	12,501	241 (44% less than conventional development)

The stormwater approach used revegetation, infiltration and vegetated swales such that the post-development run-off peaks did not exceed pre-development peaks and volumes.

Cost estimates

Table 16 provides a detailed breakdown of costs related to a conventional subdivision and an LID approach. The cost categories are different from the first three case studies due to the difference in data availability. The total costs are comparable from a relative context.

Table 16

Tharpe Knoll case study: conventional development versus LID development – schedule of costs.

Item	Standard subdivision ($)	LID subdivision ($)
Clearing and earthworks	Not calculated	Not calculated0
Pavement construction	464,550	175,525
Sanitary sewers	Not calculated	Not calculated
Stormwater drainage system	77,600	54,050
Water reticulation	Not calculated	Not calculated
Trenching/ducting/cabling	Not calculated	Not calculated
Concrete works	19,500	5200
Dayworks and general·	Not calculated	Not calculated
Reforestation	0	10,825
Total	**561,650**	**244,800**
The "dayworks and general" category costs are those costs that involve changes from the original proposal. It can include unexpected costs and changes in hourly rates or can be due to additional work needs.		

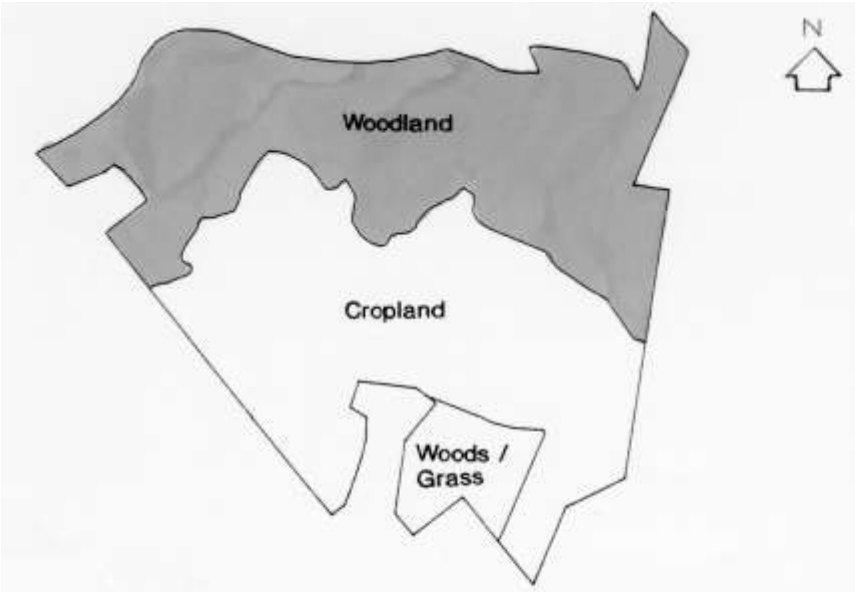
Site gross realisation

A site gross realisation was not done for this project.

7.7 Case study 7: Pleasant Hill Farm

The Pleasant Hill Farm case study is in the State of Delaware in the United States. Pleasant Hill Farm, as shown in its pre-development condition in Figure 22, has a site area of 34 hectares, has a pre-development land use of horticultural land and bush, and drains into a river that subsequently drains to a tidal estuary.

Figure 22
Pleasant Hill Farm pre-development site plan.



The conventional development proposed 90 lots with an average lot size of 1700 m^2. There is a reserve area on the site of 13.8 hectares that is floodplain area. Earthworks and total earthworks volumes were not calculated independently. Site imperviousness is 26.2 percent.

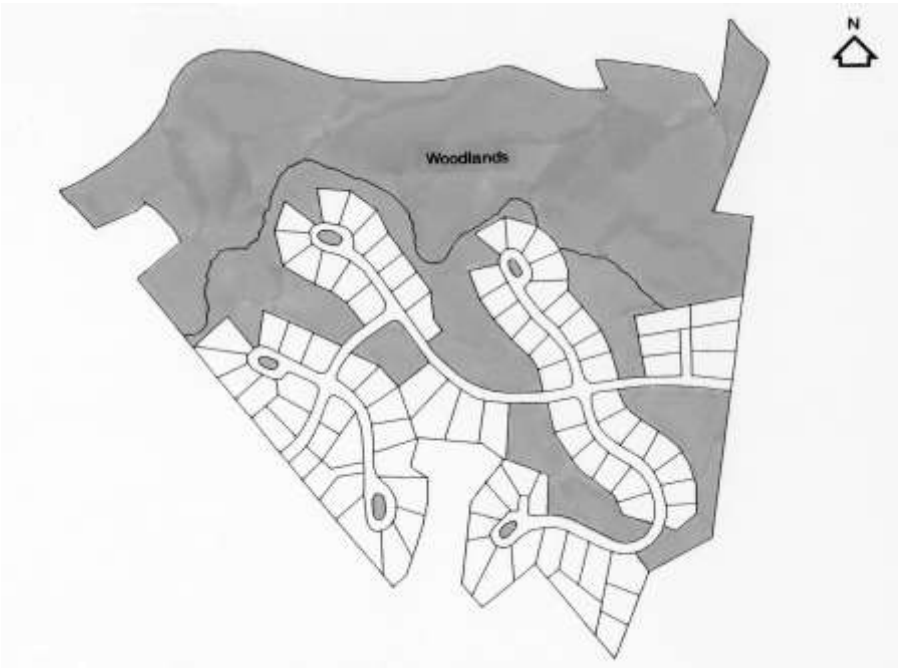
Figure 23 shows site development using a conventional development approach.

Figure 23
Pleasant Hill Farm conventional site development plan.

The LID subdivision also proposes 90 lots with a cluster approach to housing where each lot is 900 m^2. Stormwater treatment is provided by swales and revegetation practices. The community open space is 60 percent or 20 hectares with a commensurate reduction in earthworks area and volume. Site imperviousness is 10.7 percent.

Figure 24 shows site development from an LID perspective.

Figure 24
Pleasant Hill Farm LID site development plan.



Stormwater run-off volumes

Table 17 provides information on stormwater run-off from an annual context for a conventional versus an LID approach..

Table 17
Pleasant Hill Farm case study: annual stormwater run-off volumes and percentages related to pre-development conditions.

Land Use	Annual run-off volume (m^3)	Percentage increase from pre-development condition (%)
Pre-development	9985	-
Conventional development	94,878	950
LID development	43,511	436 (54% less than conventional development)

The stormwater approach used revegetation, infiltration and vegetated swales such that the post-development run-off peaks did not exceed pre-development peaks and volumes.

In this case, run-off increases are significantly greater on sites with sandy soils than clay soils. Impervious surfaces dramatically reduce infiltration and groundwater recharge.

Cost estimates

Table 18 provides a detailed breakdown of costs related to a conventional subdivision and an LID approach. The cost categories are different from the first three case studies due to the difference in data availability. The total costs are comparable from a relative context.

Table 18

Pleasant Hill Farm case study: conventional development versus LID development – schedule of costs.

Item	Standard subdivision ($)	LID subdivision ($)
Clearing and earthworks	Not calculated	Not calculated0
Pavement construction	1,020,000	527,000
Sanitary sewers	Not calculated	Not calculated
Stormwater drainage system	210,800	124,550
Water reticulation	Not calculated	Not calculated
Trenching/ducting/cabling	Not calculated	Not calculated
Concrete works	53,300	28,600
Dayworks and general	Not calculated	Not calculated
Reforestation	0	47,385
Total	**1,284,100**	**728,035**
The "dayworks and general" category costs are those costs that involve changes from the original proposal. It can include unexpected costs and changes in hourly rates or can be due to additional work needs.		

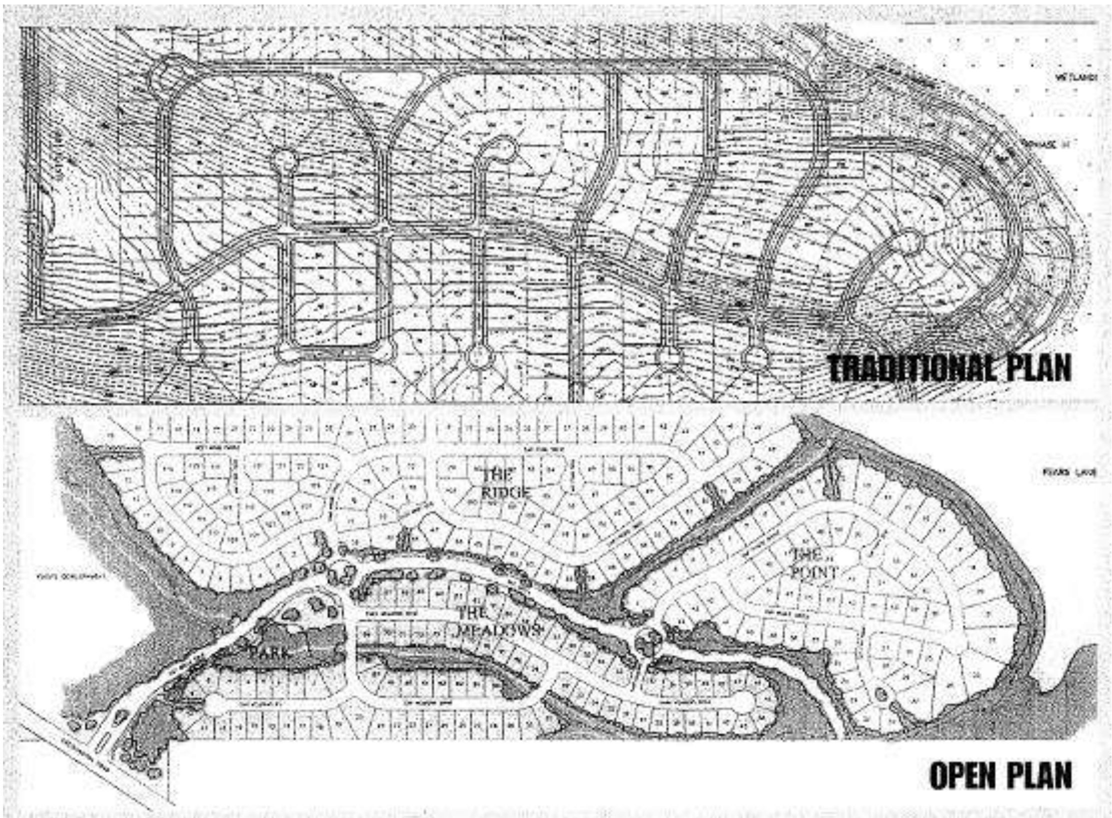
Site gross realisation

A site gross realisation was not done for this project.

7.8 Case study 8: Gap Creek

The Gap Creek case study is in the State of Arkansas in the United.States. Documentation of pre-development site conditions were unavailable, but the site was probably bush as shown in Figure 25. Gap Creek has a site area of 52 hectares.

Figure 25
Conventional and LID approaches to Gap Creek development.



The developer took a "green" approach to site development by implementing a variety of practices to reduce the environmental impact of the development. The approach resulted in significant economic benefits derived from a combination of lower development costs, higher lot yield and greater lot values.

LID principals that were used included streets at natural site grade, preservation of native vegetation, preservation of natural drainage features and a network of buffers and greenbelts that protect sensitive areas. The developer also maximised the number of lots that abut open space areas increasing marketability and increasing property values.

Streets were narrowed from 10.9 metres to 8.2 metres and kerbing was eliminated.

Cost estimates

Table 19 provides information on the site from a development and financial context.

Table 19

Projected results from total development.

Total site	**Conventional development**	**LID development**
Lot yield	358	375
Linear street length	6635 metres	6439 metres
Linear collector street lengths	2243 metres	0 metres
Linear drainage pipe	3078 metres	2052
Drainage structures: inlets/boxes/headwalls	103	79
Estimated cost per lot	$12,907	$10,512
Actual results from first phase of development		
Phase 1	Conventional development (Engineers estimated figures)	LID Development (actual figures)
Lot yield	63	72
Total cost	$1,028,544	$828,523
Total cost per lot	$16,326	$11,507

Economic and other benefits from LID development	
Higher lot yield	17 additional lots
Higher lot value	$3000 more per lot over competition
Lower cost per lot	$4800 less cost per lot
Enhanced marketability	80% of lots sold in first year
Added amenities	9.5 hectares of green-space parks
Total economic benefit	More than $2,200,000 added to profit

Site gross realisation

A site gross realisation was not done for this project but the site was developed using an LID approach and the LID costs are actual costs. The total economic benefit was that more than $2,200,000 was added to profit than would have been expected from a conventional approach to site development.

7.9 Case study 9: Auburn Hills

The Auburn Hills case study is in the State of Wisconsin in the United.States. Documentation of pre-development site conditions could not be obtained but the site was probably a mixture of bush and agricultural land. Auburn Hills has a site area of 34.2 hectares.

The site was developed as an LID subdivision so the conventional approach to development was assessed for demonstration purposes only. Forty percent of the site is preserved as open space, which included existing wetlands, green space and natural plantings and walking trails. The subdivision was designed to include open swales and bioretention for stormwater management.

The conventional subdivision proposed126 lots and the LID subdivision approach 113 single family homes and 13 attached dwellings giving a total of 126 lots. The conventional and LID site design approaches are shown in Figure 26.

Figure 26
Auburn Hills conventional and LID site design approaches.

Cost estimates

To determine potential savings from using LID, the site construction costs were compared with the estimated cost of building the site as a conventional subdivision. The developer (Bielinski Homes) compared costs not only in construction but also development-related finances such as consent fees required by local authorities;

professional expenses for site analyses, site planning and design; financing expenses such as loans and legal fees; and real estate taxes that developers are required to pay.

The cost comparisons are shown in Table 20.

Table 20

Auburn Hills conventional development versus LID development – schedule of costs.

Description	Conventional development ($)	LID development	Cost savings (%)
Site preparation	699,250	533,250	24
Stormwater management	664,276	241,497	64
Sanitary sewer	671,020	485,520	28
Water distribution	858,670	777,160	9
Utilities	290,510	177,920	39
Site paving and footpaths	771,859	584,242	24
Landscaping	225,000	240,000	-7
Construction cost subtotal	**4,180,585**	**3,039,589**	**27**
Consent fees	80,000	47,500	41
Professional services	218,750	217,600	1
Financing expenses	358,000	244,000	32
Real estate tax	69,500	69,500	0
Finance cost subtotal	**726,250**	**578,600**	**20**
Total costs	**4,906,835**	**3,618,189**	**26**
Summary	3,090 linear metres of roads in LID versus 3505 linear metres in conventional development.		
	Construction cost per metre of roadway: $1401 for LID development. Versus $1171 for conventional development.		
	Construction cost per unit: $26,030 for LID development versus $38,943 for conventional development.		
	113 lots/13 duplex apartments in LID versus 126 lots in conventional development.		

The clustered design used in the development protected open space and reduced clearing and grading costs. Costs for paving and footpaths were also decreased as the cluster design reduced street length and width. Stormwater savings were realized primarily through the use of vegetated swales. These LID practices provided stormwater conveyance and treatment and also lowered the cost of conventional stormwater infrastructure. The increase in landscaping costs resulted from additional open space present onsite compared to a conventional design, as well as increased street sweeping. Overall, the subdivision's LID design retained more natural open space for the benefit and use of the homeowners and aided stormwater management by preserving some of the site's natural hydrology.

Site gross realisation

A site gross realisation was not done for this project and the actual profit relating to it was not reported.

Figure 27
Auburn Hills subdivision as development is occurring