2.0 Low Impact Development

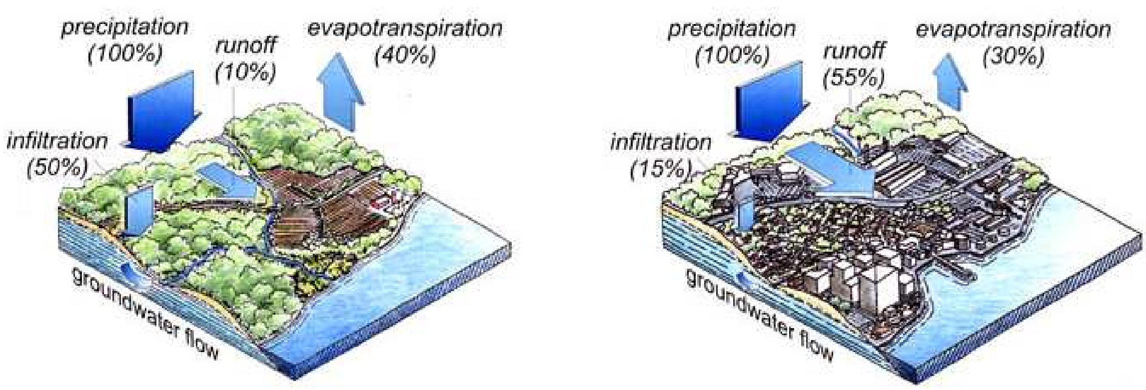
2.1. What is Low Impact Development (LID)?

LID is an approach to land development that uses various land planning techniques, design practices and technologies to simultaneously conserve and protect natural resource systems. It is an innovative multi-step storm water management approach that 1) utilizes thoughtful site planning and 2) manages rainfall at its source through the use of integrated and distributed micro-scale storm water practices.

Examples of thoughtful site planning include: the preservation/protection of environmentally sensitive site features such as riparian buffers, wetlands, steep slopes, valuable (mature) trees, flood plains, woodlands, and highly permeable soils. Examples of integrated and distributed micro-scale storm water practices include: bioretention, permeable pavers, flow through planters, disconnected downspouts, rain barrels, and green roofs, among others (refer to section 4). Ultimately, natural hydrologic functions such as storage, infiltration, evaporation, transpiration, and groundwater recharge are used to their fullest potential to help minimize the amount of storm water runoff that must be managed. This helps users to control pollutants, reduce runoff volume, manage runoff timing, and address other ecological concerns.

In contrast, conventional land development techniques typically begin with clearing and grading the entire parcel, resulting in the removal of all vegetation. The next development steps traditionally include paving areas for roads and parking, building structures, and landscaping areas. This results in large amounts of impervious surface which prohibits storm water from infiltrating into the ground to replenish the groundwater or supply local streams and wetlands with baseflow. In order to manage the large amount of runoff generated from the impervious surface created from development, engineers then design structural storm water controls such as catch basins, pipes, and detention ponds.

Figure 2.1.1: Impacts of Typical Development to the Natural Water Balance



(Smart Growth Tool Kit, 2007)

Figure 2.1.1 shows the impact typical development has on the natural hydrologic cycle. As mentioned above, typical development creates large areas of impervious surface, which prevents infiltration and subsequently generates larger runoff volumes. Under natural predevelopment conditions, more rain infiltrates through soils and percolates downward to the groundwater table.

Fact sheets for a number of onsite storm water reduction practices are provided in Section 4.

4.1 Green Roofs: A green roof (vegetated roof/eco roof/roof garden) is a system consisting of waterproofing material, growing medium and vegetation. A green roof can be used in place of a traditional roof as a way to limit impervious site area and manage storm water runoff.

4.2 Permeable Pavement: Permeable Pavement provides the structural support of conventional pavement, but allows storm water to drain directly through the surface into the underlying stone base and soils, thereby reducing storm water runoff. There are permeable varieties of asphalt, concrete, and interlocking pavers. Permeable pavements are designed with an open graded stone sub-base that allows water to pass through to the native soil and provides temporary storage.

4.3 Rain Water Harvesting: Rain barrels, cisterns, and tanks are structures designed to intercept and store runoff from rooftops. Rain barrels are used on a small scale while cisterns and tanks may be larger.

4.4 Filter Strips: Filter Strips are densely vegetated lands that treat sheet flow storm water from adjacent pervious and impervious areas. They function by slowing runoff, trapping sediment and pollutants, and in some cases infiltrating a portion of the runoff into the ground.

4.5 Bioinfiltration/Bioretention/RainGarden: Bioretention areas typically are landscaping features adapted to treat storm water runoff. Bioretention systems are also known as Mesic Prairie Depressions, Rain Gardens, Infiltration Basins, Infiltration swales, bioretention basins, bioretention channels, tree box filters, planter boxes, or streetscapes, to name a few. Bioretention areas typically consist of a flow regulating structure, a pretreatment element, an engineered soil mix planting bed, vegetation, and an outflow regulating structure.

4.6 Low Impact/Retentive Grading: Low Impact Grading techniques focus on utilizing existing topography during Site layout to minimize cost. Proposing structures, roads, and other impervious surfaces along existing high ground will allow for storm water to drain onto adjacent storm water utilities with a minimum of earthwork required.

4.7 Swales: A swale is a vegetated open channel, planted with a combination of grasses and other herbaceous plants, shrubs, or trees. A traditional swale reduces peak flow at the discharge point by increasing travel time and friction along the flow path.

4.8 Subsurface Infiltration: Subsurface infiltration systems are designed to provide temporary below grade storage infiltration of storm water as it infiltrates into the ground. Dry wells, infiltration trenches and beds are a few examples of these types of systems.

4.9 Inlet and Outlet Control: Inlet and Outlet controls are the structures or landscape features that manage the flow into and out of a storm water management facility. Flow splitters, level spreaders, curb openings, energy dissipaters, traditional inlets, and curbless design are all examples and elements of inlet controls.

4.10 Filters: Filters are structures or excavated areas containing a layer of sand, compost, organic material, or other filter media. They reduce pollutant levels in storm water runoff by filtering sediments, metals, hydrocarbons, and other pollutants.

4.11 Subsurface Vaults: Subsurface Vaults are specialized underground structures designed similarly as above ground detention or retention basins. These underground basins can be utilized for groundwater recharge by allowing infiltration.

4.12 Detention Basin: Detention Basins can be a cost effective method to provide temporary storage, conveyance, and treatment of runoff when used within the context of Low Impact Development (LID) strategies. Long, linear, interconnected basins can provide the designer with an economically attractive method to provide source control of storm water as well as convey water without the slope and cover requirements of conventional storm sewer design.

2.2. Why use LID (Incentives)?

2.2.1. Ancillary Benefits from LID Storm Water Management Techniques

LID storm water management techniques can be used to meet supplementary goals (or in many instances other existing City regulations) in addition to meeting the existing storm water requirements. A development or redevelopment site often has a required amount of green space or landscape requirements that must be met along with the storm water management requirements. Many LID storm water management techniques can be integrated into urban site features. In addition to meeting regulatory measures, some of the specific ancillary benefits from LID techniques/Green Infrastructure include (*EPA, 2007*):

Cleaner Water - Vegetation and green space reduce the amount of storm water runoff and, in combined systems, the volume of combined sewer overflows.

Enhanced Water Supplies - Most green infiltration approaches result in storm water percolation through the soil to recharge the groundwater and the base flow for streams.

Cleaner Air - Trees and vegetation improve air quality by filtering many air borne pollutants and can help reduce the amount of respiratory illness.

Reduced Urban temperatures - Summer city temperatures can average 10F higher than nearby suburban temperatures. High temperatures are linked to higher ground level ozone concentrations. Vegetation increases shade, reduces the amount of heat absorbing materials and emits water vapor - all of which cool hot air.

Increased Energy Efficiency - Green spaces help lower ambient temperatures by shading and insulating buildings. Thereby decreasing energy needed for heating and cooling.

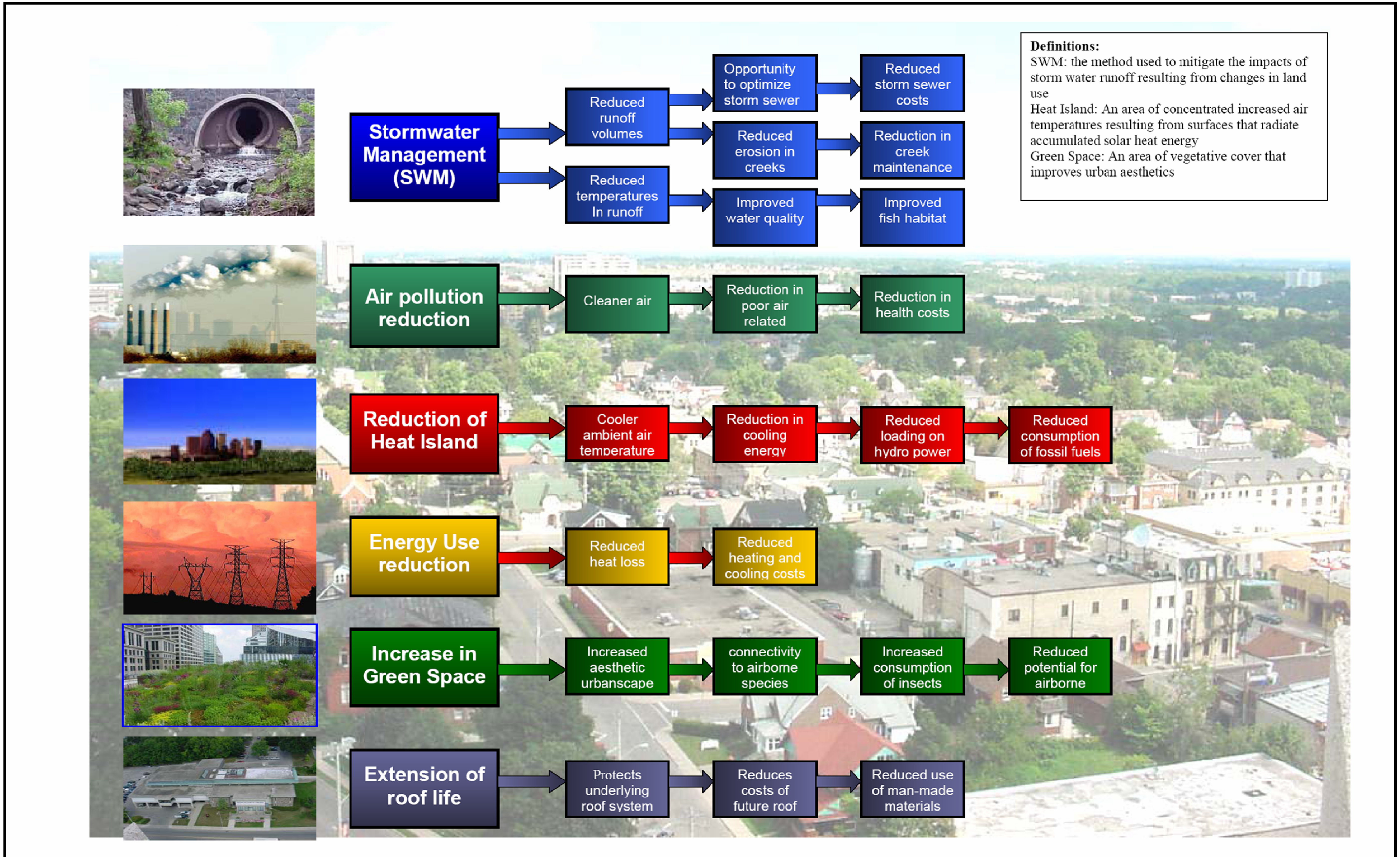
Community Benefits - Trees and plants improve urban aesthetics and community livability by providing recreational and wildlife areas and can raise property values.

Cost Savings - Green infrastructure may save capital costs on digging big tunnels and storm water ponds, operations and maintenance expenses for treatment

Leadership in Energy and Environmental Design (LEED) credits.-The LEED program is used by many organizations and communities to certify buildings as being innovative and environmentally responsible. A LEED certified facility can offer competitive advantage and increase real estate value, thus improving its marketability. Appendix 1 provides a description of potential LEED credits for various storm water management techniques.

In general, many of the green infrastructure techniques provide the ancillary benefit listed above; specifically green roofs and their associated benefits are further identified below.

Figure 2.1.2: Green Roof Technology Chain of Benefits
(TSH Associates, 2004)



There are many ancillary benefits associated with green roofs, supplemental to storm water management, as demonstrated by Figure 2.1.2. Although these benefits are well documented, there is not a wide variety of tools available to actualize these benefits monetarily. However, Green Roofs for Healthy Cities (GRHC) and the Athena Institute, with funding by TREMCO Inc, recently developed a comprehensive life cycle costing (LCC) calculator. The LCC calculator allows users to evaluate both the hard and soft costs associated with green roofs versus conventional roofing systems and cool roofing system (white roofs) over a specified time period. Provided below, in Table 2.1.1 is an example case study demonstrating this tool. In addition Appendix 2 provides a publication from TREMCO for immediate release titled *New Life Cycle Calculator Compares the Cost of Green Vegetative Roofs with Conventional Roof Systems* and an abstract titled Life Cycle Cost Calculator-Phase 1 published by Green Roofs for Healthy Cities from the 2007 Proceedings from the Greening Rooftops for Sustainable Communities Conference, Awards and Trade Show.

Table 2.1.1: Green Roof Cost Comparison to Conventional Roofing System and Cool Roofing System (www.greenroofs.net)

Common Assumptions	Input Data		
	Scenario 1	Scenario 2	Scenario 3
	Conventional Mod. Bituminous	**PVC Single Ply Cool Roof**	**Extensive Green Roof**
Project Initiation Year	2007	2007	2007
Study Period in Years	25	25	25
Applicable discount rate (%)	8	8	8
General Price Inflation Factor (%)	2.04	2.04	2.04
Thermal Fuel Energy Price Inflation Factor (%)	9	9	9
Electricity Price Inflation Factor (%)	3	3	3
Investment Data			
Investment Description	**Conventional Mod. Bituminous**	**PVC Single Ply Cool Roof**	**Extensive Green Roof**
Total Installed Capital Cost	49,728.00	41,440.00	103,600.00
Annual Electricity Energy Cost	250.00	233.00	232.00
HVAC Downsizing Capital Savings	0.00	0.00	0.00
Stormwater Control	0.00	0.00	3,850.00
Annual Maintenance Cost	761.00	557.00	306.00
Roofing Replacement Interval (in years)	16.00	12.00	25.00
Periodic Replacement Cost	48,317.00	37,140.00	491.00
Periodic Savage Value (at roof replacement)	0.00	0.00	0.00
End of Life Residual Value	16,653.00	25,548.00	23,206.00
UHI Effect Mitigation (capital cost savings)	0.00	0.00	0.00
Development Fee Reduction (capital cost savings)	0.00	0.00	2,500.00
Annual Increase in Revenue due to Roof System	0.00	0.00	2,500.00
Annual Increase in Revenue due to Productivity and Health	0.00	0.00	2,000.00
Net Capital Cost (year 0)	38,065.00	27,870.00	54,868.00
Other Annual Cost or Benefits	0.00	0.00	0.00
Financial Results Summary			
At a discount rate of (%)	8.00	8.00	8.00
NPV for study period (yrs)	-142,393.00	-136,068.00	-103,562.00
NPV at 1/3 of study period	-66,605.00	-55,014.00	-67,406.00
NPV at 2/3 of study period	-114,592.00	-101,271.00	-84,292.00
Simple Payback Period on total project investment (yrs)	Payback Period Longer than Study Period	Payback Period Longer than Study Period	Payback Period Longer than Study Period

The table above is simply an example of a tool that can be utilized when evaluating different options in project planning for a roofing system. In the example provided above, green roofs are the most favorable option for the entire projected life of the project. However, another favorable roofing option is the PVC single ply cool roof. The PVC single ply cool roof has the best value when evaluating the project at 1/3 of the study period.

A single ply cool roof can be manufactured in a bright-white color for high solar reflectance -or albedo - and increased energy savings. White single ply membranes are highly reflective, as compared to traditional bituminous roofing material, and can help reduce the urban heat island as well as save the building owner cooling costs. Another roofing option, to help reduce the urban heat island are reflective tiles. Reflective tiles are usually made of clay or concrete, and manufactures have begun to develop pigments that reflect in the infrared. Special pigments allow roofing material to keep their traditional colors, such as brown, green, and terra cotta, while reflecting away up to 70% of the sun’s energy. These products enable buyers to forego the perceived tradeoff between energy efficiency and the aesthetic concerns with a bright-white roof (EPA, 2007).

2.2.2. Reduction in Storm Water Infrastructure Sizing

In general, the storm water sizing criteria provide a strong incentive to reduce impervious cover at development and redevelopment sites (e.g., water quality and quantity). The following section provides examples of how the storm water sizing criteria, both water quality and quantity, can be used as an incentive to incorporate LID storm water management techniques into design.

2.2.3. Water Quality Volume Reduction

Storage requirements for WQ_v sizing criteria are directly related to impervious cover. Thus, significant reductions in impervious cover result in smaller required storage volumes and, consequently, lower BMP construction costs. Below is the WQ_v sizing criteria equation.

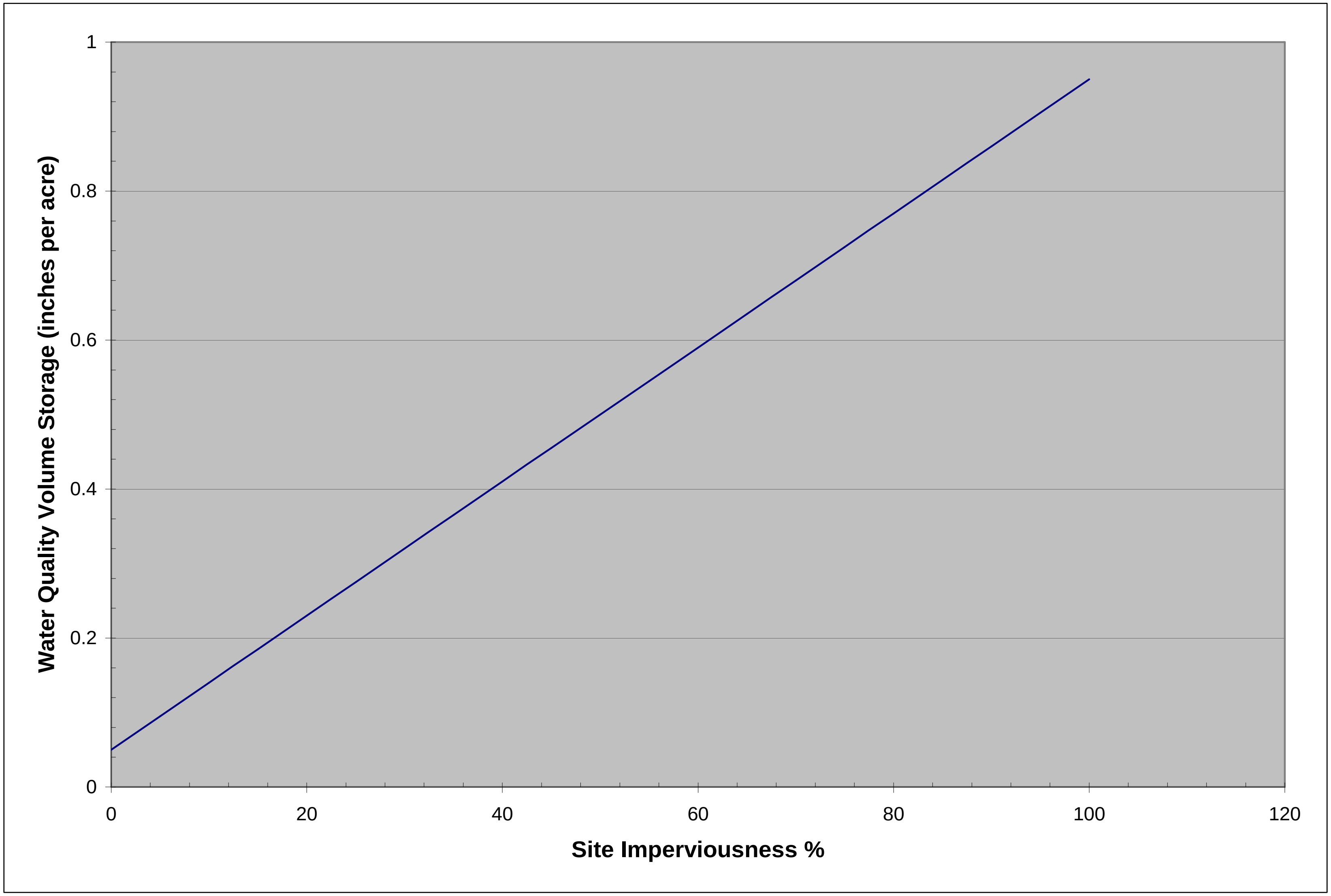
$$WQ_v = \frac{(P)(R_v)(A)}{12}$$

where:

WQ_v = water quality volume (acre-feet)
P = 1 inch of rainfall
R_v = 0.05 + 0.009(I) where I is the percent impervious cover
A = area in acres

The graphical solution to the equation is provided as Figure 2.1.3.

Figure 2.1.3: Relationship Between Required Water Quality Volume Storage and Site Imperviousness (%)



As demonstrated in Figure 2.1.3, if a developer reduces the percent (%) impervious area of a 20 acre parcel from 60% impervious to 40 % impervious by utilizing porous pavement, or other practices demonstrated in Chapter 4 (green infrastructure fact sheets) the resulting water quality volume storage to treat would be decreased from 0.59 inches/acre (11.8 inches) to 0.41 inches/acre (8.2 inches).

2.2.4. Water Quantity Reduction

A commonly used method to determine the storm water runoff depth for post development is the NRCS SCS curve number method. The major factors that determine the runoff curve number are the hydrologic soil group (HSG), land cover type, land treatment, hydrologic condition, and antecedent runoff condition. The NRCS (SCS) runoff equation is as follows:

$$Q_v = \frac{(P\ I_a)^2}{(P\ I_a) + S_m}$$

where:
Q_v = runoff (inches)
P = rainfall (inches)
S_m = potential maximum retention after runoff begins
I_a = initial abstraction

The SCS has found the I_a to be approximated by the following empirical equation:

$$I_a = 0.2\,S_m$$

By substituting Equation 205.02 into Equation 205.01, the following runoff equation is derived:

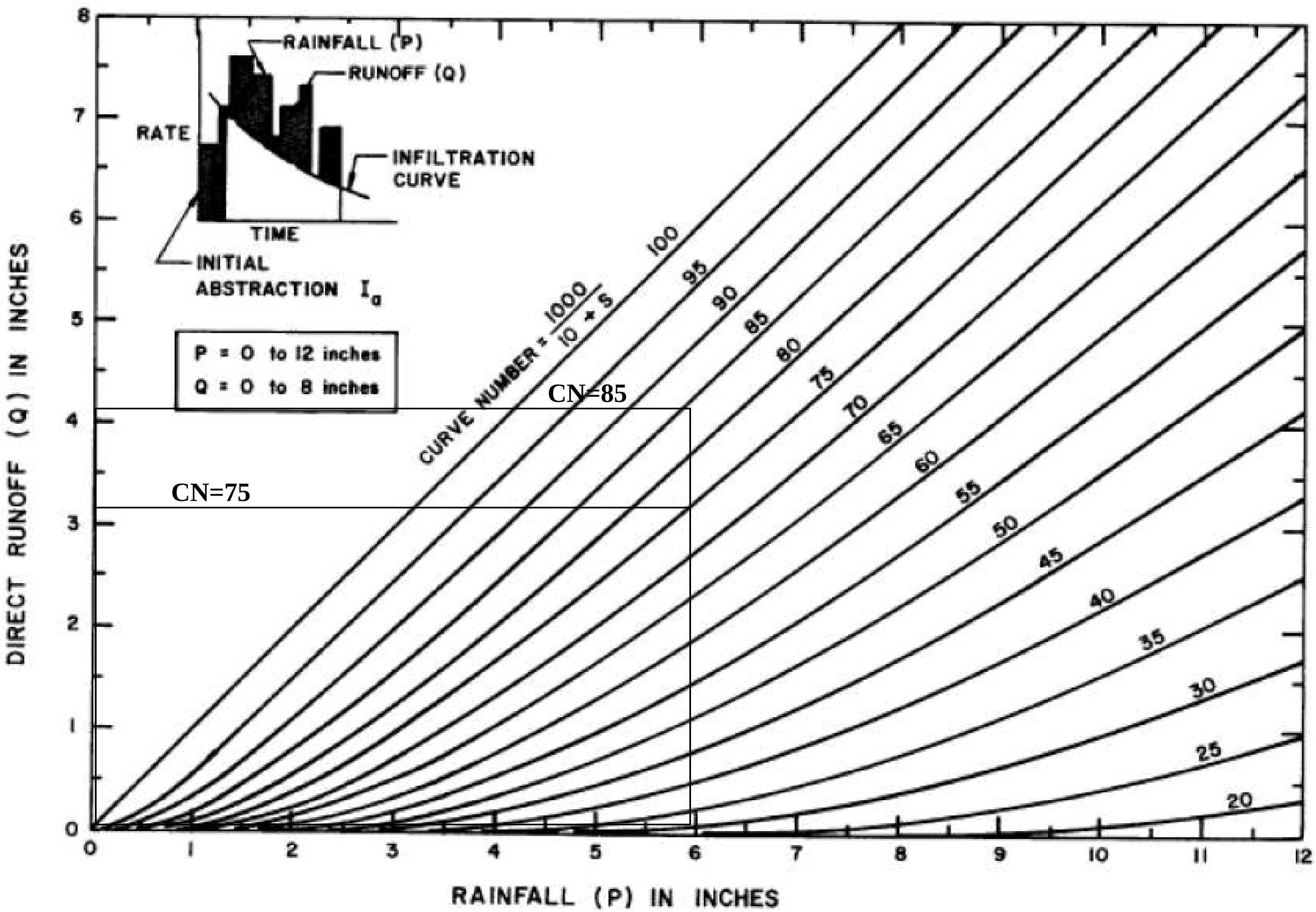
$$Q_v = \frac{(P0.2\,S_m)^2}{P + 0.8\,S_m}$$

The value of S_m is related to the soil and cover conditions of the watershed through the CN. The value of CN has a range of 0 to 100, and S_m is related to CN by the following equation:

$$S_m = (1000/CN) - 10$$

Each of the land use types is assigned a CN. The CNs are traditionally used as a factor to estimate the characteristic runoff from a land surface area as a function of the rainfall amount and pattern. A graphical solution to the runoff equation is provided in Figure 2.1.4:

Figure 2.1.4: SCS Solution of the Runoff Equation
(Source: SCS, TR-55, Second Edition, June 1986)



As demonstrated by Figure 2.1.4, approximately 4.1 inches of direct runoff would result if 5.8 inches of rainfall occurs on a watershed with a curve number of 85. In contrast, approximately 3.1 inches of direct runoff would result if the same 5.8 inches of rainfall occurs on a watershed with a curve number of 75. The amount of direct runoff (Q_v) can be reduced by lowering the CN.

The designer can compute curve numbers (CN) based on the actual measured impervious area at a site using:

$$CN = \frac{(98)I + \sum (CN)(P)}{A}$$

Where:

CN = curve number for the appropriate pervious cover
I = impervious area at the site
P = pervious area at the site
A = total site area

An example of a conventional site design with the computed CN is provided below. The same site is then designed using various LID storm water management techniques and the resulting CN computation is provided. *(The following example problem is from the Milwaukee Metropolitan Sewerage District: Surface Water and Storm Water Rules Guidance Manual Low Impact Development Documentation 2005: Refer to Appendix 3 for further description of a LID design and review spreadsheet that allows users to quickly evaluate various LID techniques to reduce the detention requirement.)*

Figure 2.1.5: Conventional Site Example
(MMSD Low Impact Development Documentation, 2005)

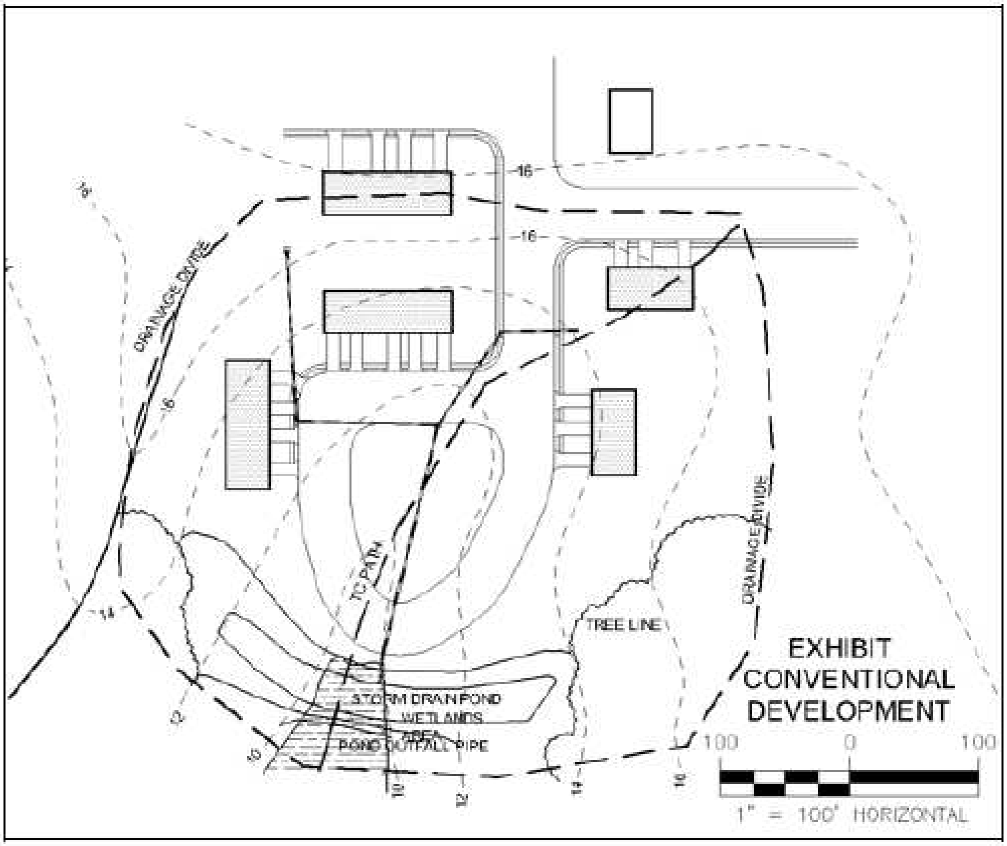


Table 2.1.2: Area-Weighted CN Calculation for Conventional Design
(MMSD Low Impact Development Documentation, 2005)

Hydrologic Soils Group	Cover Description	CN (Table 2-2 TR-55)	Area (Acres)	Product of CN x Area
B	Lawn (fair condition)	69	3.2	220.8
B	Woods, Fair	60	0.7	42.0
B	Impervious	98	2.6	254.8
			Sum of Products	**517.6**
			Divided by Drainage Area	6.5
			Weighted CN	**80**

Figure 2.1.6: LID Site Example
(MMSD Low Impact Development Documentation, 2005)

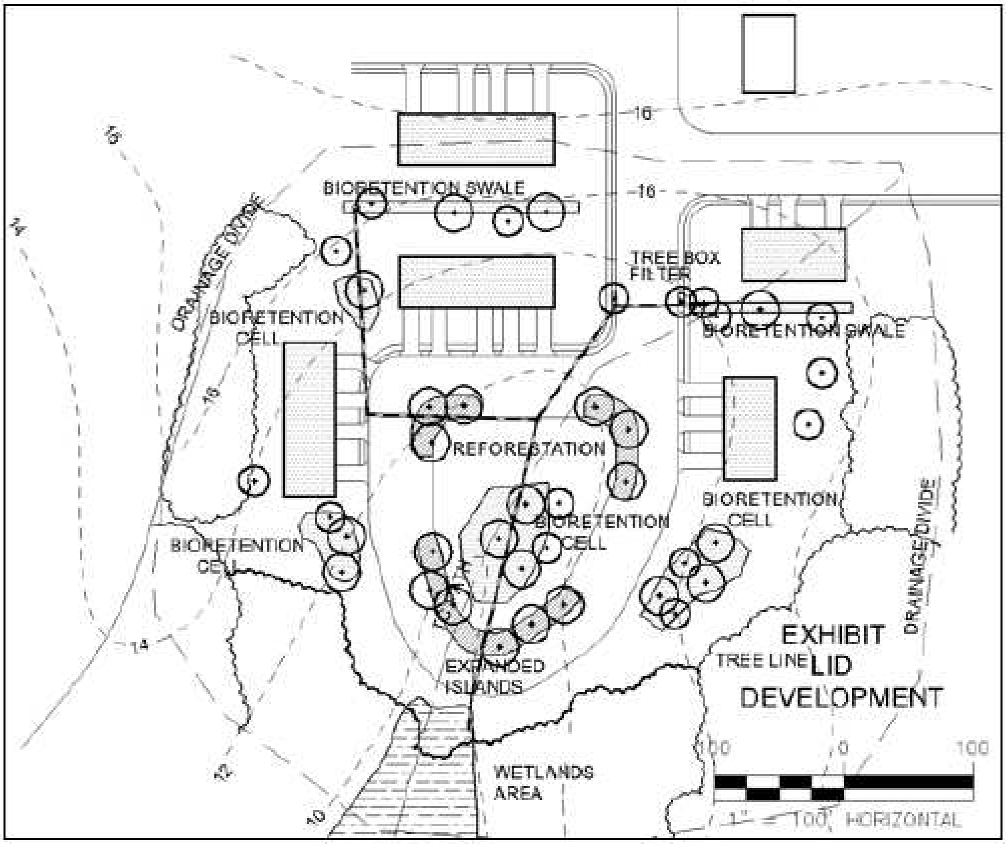


Table 2.1.3: Area Weighted CN Calculation for LID Design
(MMSD Low Impact Development Documentation, 2005)

Hydrologic Soils Group	Cover Description	CN (Table 2-2 TR-55)	Area (Acres)	Product of CN x Area
B	Lawn (good condition)	61	1.8	109.8
B	Woods, Fair	60	2.5	150.0
B	Impervious	98	2.2	215.6
			Sum of Products	**475.4**
			Divided by Drainage Area	6.5
			Weighted CN	**73**

Figures 2.1.5 and 2.1.6 demonstrate conventional and LID site plans for a 6.5 acre residential townhouse development. Tables 2.1.2 and 2.1.3 demonstrate the weighted curve number calculation for each site. The reduction in the curve number from 80 to 73, was achieved primarily by increasing the amount of wooded area. In addition several bioretention areas (rain gardens), and tree box filters were integrated into the design.

According to the standard NRCS runoff depth calculation, for a 2.57-inch storm the lower curve number will reduce the depth of runoff from 0.9 to 0.6 inches. For this specific example, when the bioretention (rain gardens) that have an average ponding depth of 6 inches and a subsurface storage capacity of 3 inches, the LID spreadsheet (provided in Appendix 3), indicates that only 2.2% of the site area is needed to reduce the peak flow to a target level of 0.15 cfs/acre. Without the reduction in curve number, approximately 5.0% of the area would be needed.

Figure 2.1.7 and 2.1.8 are conceptual design examples completed to compare conventional storm water design with low impact development. The conceptual site design examples provide a detailed analysis for both a redevelopment and new development site consisting of: site layouts, water quality and quantity calculations, and landscape requirements for both a traditional site layout and an LID layout. The complete redevelopment and new development site reports are provided as Appendix 5 and Appendix 6, respectively.

Figure 2.1.7: Redevelopment Site Design Example Conventional vs. LID

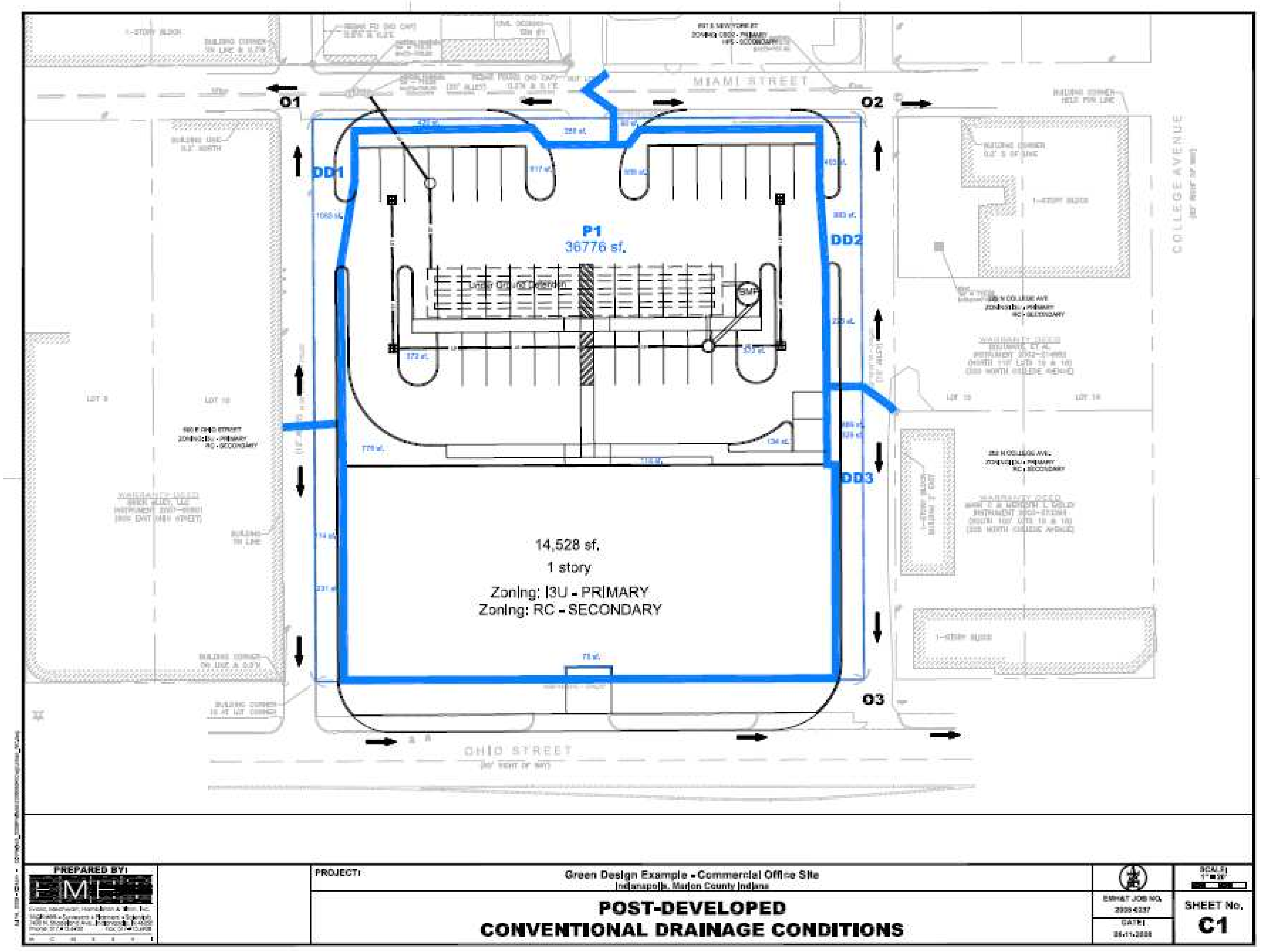


Figure 2.1.7: Redevelopment Site Design Example Conventional vs. LID, cont.

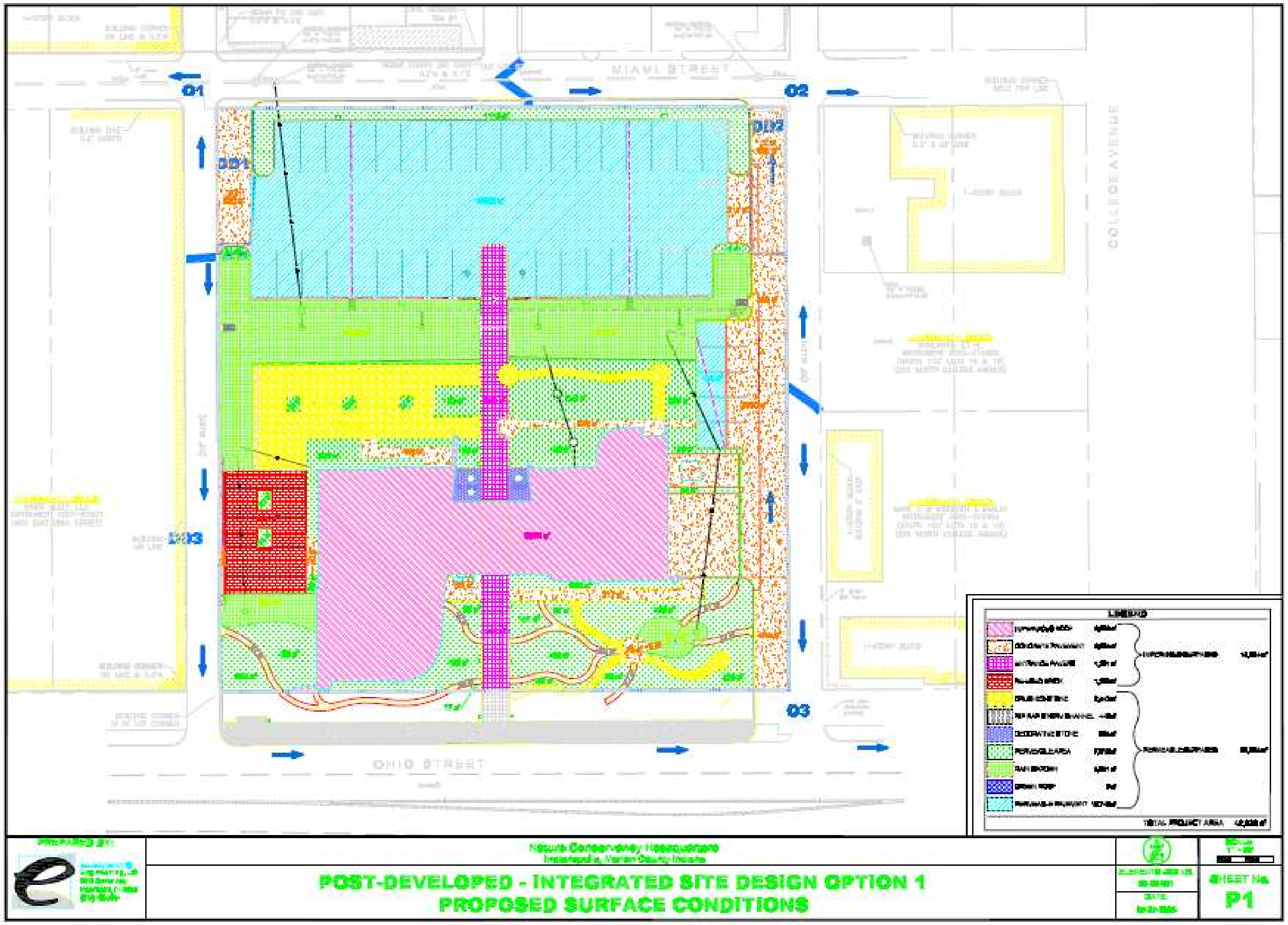
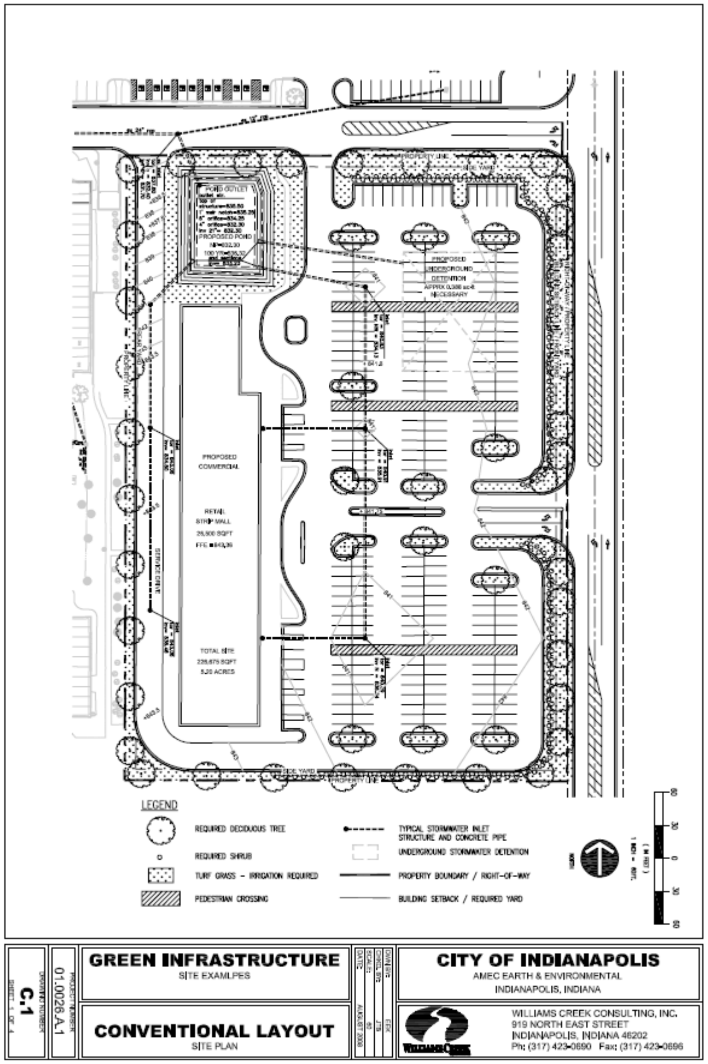
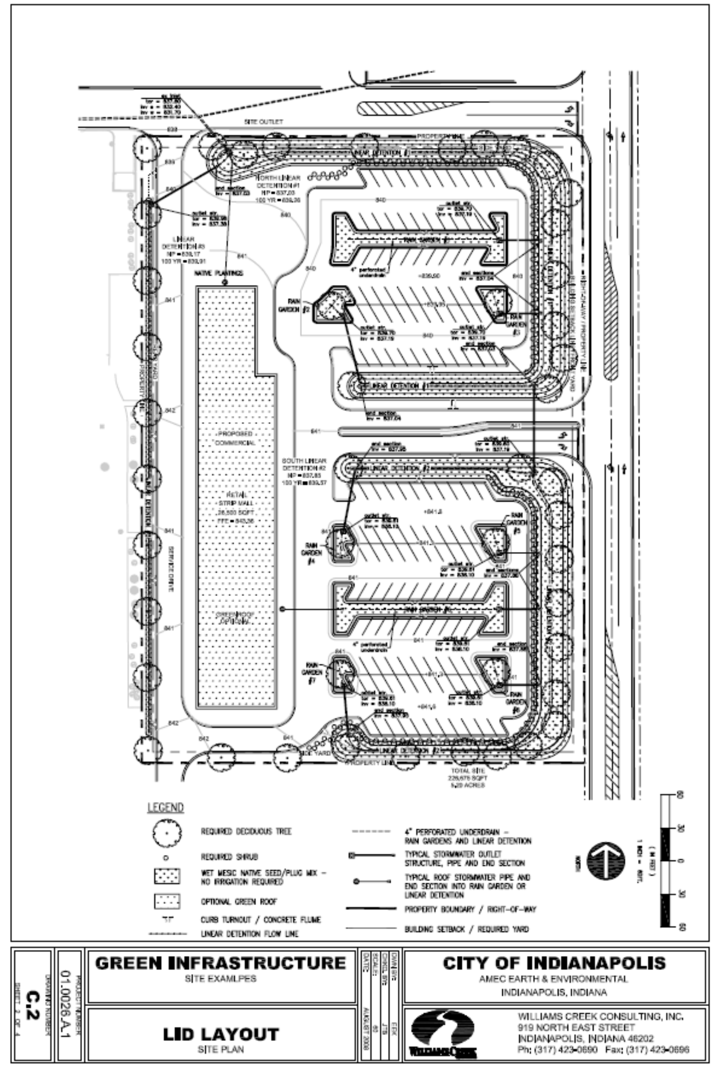


Figure 2.1.8: New Development Site Design Example Conventional vs. LID





2.2.5. Reduction in Storm Water Utility Fee

The Common Council of the City of Fort Wayne, Indiana passed Ordinance G-11-07, which created a Department of Strom water Management within the Division of City Utilities as provided in IC 8-1.5-5. The ordinance, codified as Chapter 53 of the Fort Wayne Code of Ordinances, establishes a Stormwater Management District, extending to the corporate boundaries of the city, for the purpose of providing for the collection and disposal of stormwater in a manner that protects the public health and welfare.

Storm water user fees have been established on the basis of the amount of impervious surface area, as the amount of storm water runoff a property generates is directly related to the amount of hard surface (rooftops, parking lots, driveways) on that piece of property. A statistical sampling of residential properties within the City determined that, on average, a developed single-family residential property has 2,500 square feet of impervious area. As a result, 2,500 square feet is used as the base billing unit or Equivalent Residential Unit (ERU).

Each single-family residential property is assigned a flat rate bill of one (1) ERU. The billing rate applied to each ERU is $3.65 per month (check City of Fort Wayne website for current rate as it is periodically adjusted). Each non-residential property is then measured and its impervious surface is translated into ERUs (rounded to a whole number). That number, multiplied by the unit billing rate per ERU, yields the monthly storm water user fee for that particular property. The number of ERUs assigned to a non-residential property will remain constant unless any changes are made on the property that alter its impervious surface area. Impervious area records are maintained and updated as necessary by Fort Wayne's Geographic Information System (GIS) Department.

By reducing the effective impervious footprint of new development or redevelopment, and thus the amount of storm water runoff that the City must manage, the property owner can reduce his/her fee either directly by reduction of impervious surface or through the credit program by using BMPs that reduce the "effective" imperviousness of the site.

2.2.6. Analysis of Storm Water Fee Incentive

The use of low impact development (LID) techniques/green infrastructure is a way that property owners can reduce their impact on the City's stormwater management system and thus reduce their stormwater utility fees. A simple example of the financial impact of utility fees as a function of percent (%) impervious area is provided in Table 2.1.4. The costs are based on a 20 acre parcel with varying percent (%) impervious cover. The analysis provides an annual storm water fee and the net present value analysis for 20 years of utility fee payment (assuming a 3% discount rate). The analysis was completed based on the current utility fee of $3.65/ERU/month.

Storm Water Utility Fee Calculation Example
Site Area=20 acres
Site Impervious Area=15 acres
Site Impervious Area =15 acres * 43,560 sqft/acre
Site Impervious Area =653,400 sqft
1 ERU=2,500 sqft
1 ERU = $3.65/month
Annual Storm Water Utility Fee = (653,400 sqft/2,500 sqft) *$3.65/month *12 month
Annual Storm Water Utility Fee = $11,431.80

Table 2.1.4: Example Storm Water Utility Fee Calculation

Example	
Development Area	20 Acres
Storm Water Utility Fee	$3.65/ERU/Month

%Impervious	**Storm Water Utility Fee (Annual)**	**Storm Water Utility Fee (20 year Net Present Value)**
0	$0.00	$0.00
10	$1,362.81	$20,883.36
20	$2,725.61	$41,766.72
30	$4,088.42	$62,650.08
40	$5,451.22	$83,533.44
50	$6,814.03	$104,416.80
60	$8,176.83	$125,300.17
70	$9,539.64	$146,183.53
80	$10,902.45	$167,066.89
90	$12,265.25	$187,950.25
100	$13,628.06	$208,833.61

The relationship between percent (%) impervious area and storm water utility fee is directly proportional. By decreasing the amount of impervious area at a development site, the storm water utility fee will subsequently be reduced. It is important for many development projects to add the storm water utility fee into the life cycle cost analysis for the site. Evaluating this over the projected project life will provide further incentive to the property owner to invest in the LID techniques.

2.2.7. Options for Small Spaces/Redevelopment Areas

Redevelopment of downtown properties is a significant issue for storm water management and combined sewer programs around the globe. In many, if not most instances, these areas are characterized by wall to wall imperviousness, undersized storm water infrastructure, and a growing demand to redevelop the space. In Fort Wayne, redevelopment interests exist both in the downtown area and in older suburban residential and commercial areas.

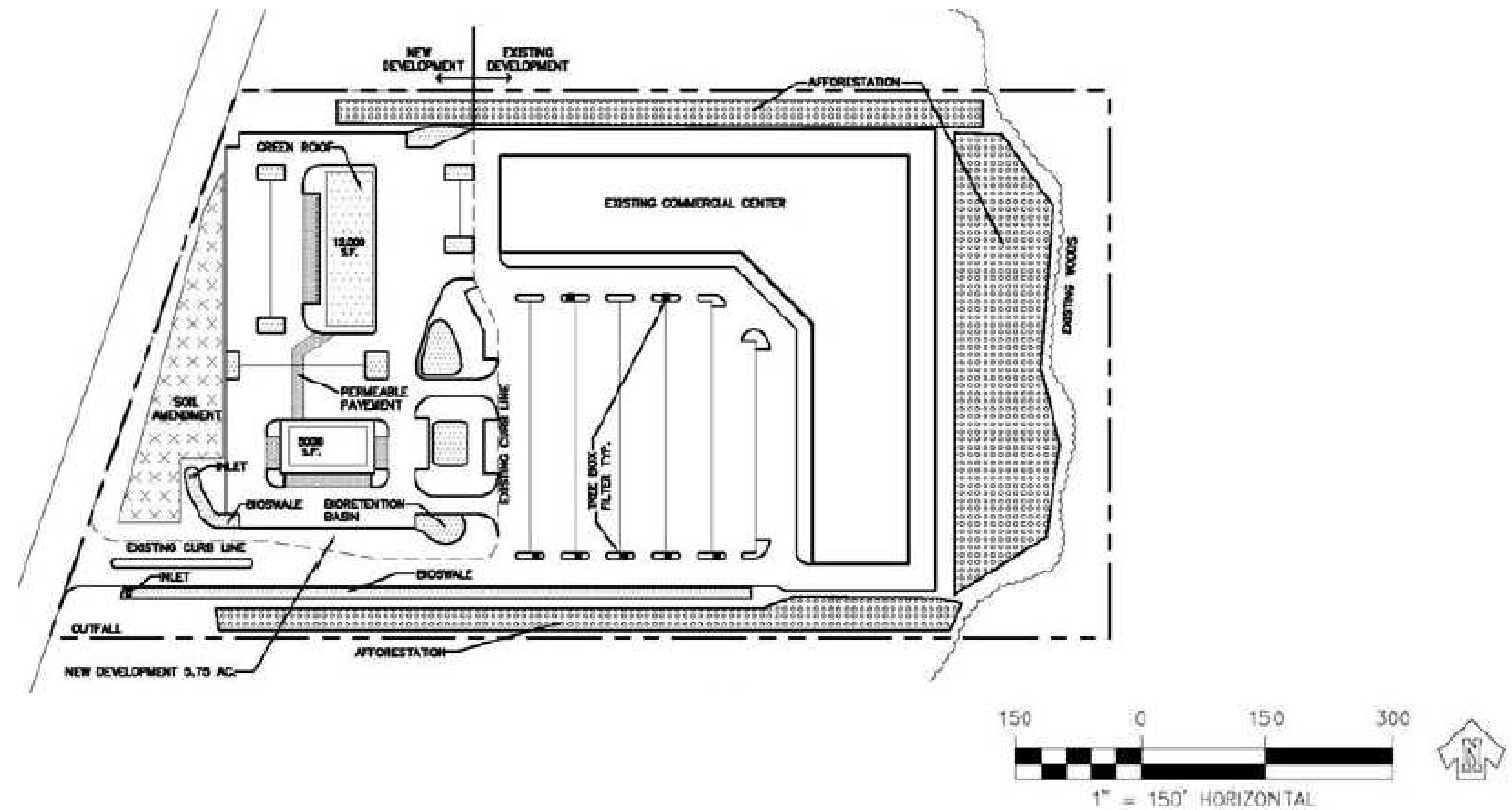
Often times, there is not enough land area for traditional storm water management, or in many instances the land area is very valuable and developers do not want to loose the potential profits generated from the developable space. Green infrastructure techniques provide various decentralized storm water management methods to address these issues developers might face.

Many older suburban and commercial properties throughout Allen county are being redeveloped. These areas must also comply with the City's storm water regulations and are areas that would possibly benefit from incorporating LID techniques/green infrastructure.

An example of a commercial redevelopment that integrates various LID techniques/green infrastructures is provided in Figure 2.1.9 (The following design *example is from Low Impact Development for Big Box Retailers, November 2005*). This case study illustrates the potential for the retrofit of an existing strip shopping center with water quality management practices as part of a redevelopment plan. The redevelopment includes a drive-through fast-food facility and a new retail strip. Storm water quantity and quality control are provided for these areas. A retrofit of the existing impervious areas with water quality controls is also shown.

As described above, two conceptual site design examples (redevelopment and new development) demonstrating alternative configurations and multifunctional landscape areas are provided as Appendix 5 and Appendix 6. The conceptual site design examples provide a detailed analysis consisting of: site layouts, water quality and quantity calculations for both a traditional site layout and an alternative LID layout.

Figure 2.1.9: Redevelopment LID Water Quality Design Example
(Low Impact Development for Big Box Retailers, 2005)



Existing Commercial Development Retrofit

- The total site area is 20.5 acres. An existing strip mall is located on the eastern 14.75 acres.
- The western 5.75 acres is being developed as a fast-food drive through and small strip retail shops.
- For the western 5.75 acres, demonstrate how to provide storage for the water quality volume (WQV) and to provide detention to limit the 10-yr, 2-hr peak discharge rate to the predevelopment condition.
- Assume that providing storage for 3” of runoff from the post-development impervious area will provide required detention storage for the 10-yr, 2-hr storm.
- WQV = 0.5” of runoff over impervious area.
- Assume drainage area for western section is limited to the 5.75 acres in that section (no offsite runoff, or runoff from the eastern section).

Existing Conditions

- The site drains from northeast to southwest. Slops are from 2 to 3 percent.
- The eastern section has 8.9 acres of impervious area.
- The western section is undeveloped.

Post-Development Conditions

- The western section has 3.4 acres of impervious area.
- Soil amendments are added to 0.66 acres in the western section, increasing the area’s infiltration capacity.
- 2.9 acres across the entire site are afforested.

Result – New Development

- Water quality volume = 6,200 C.F.
  - o WQV = 0.5” / (12” per foot) * 3.4 acres * (43,560 S.F. per acre)
- **Detention volume = 37,000 C.F.**
  - o Detention volume = 3” / (12” per foot) * 3.4 acres * (43,650 S.F. per acre)
- WQV is contained within the detention volume; therefore, BMPs will be sized to contain the detention volume.

BMPs – New Development

- Use a combination of bioretention basins, bioswales, permeable pavement, and green roof.
- Bioretention basins and bioswales are designed so that surface ponding drains within 24 hours.
- BMPs are sized to collectively capture 3” of runoff from the post-development impervious area.
- One (1) 11,000 S.F. green roof
  - o Covers entire 12,000 S.F. roof of strip retail ships except utility areas and access points.
  - o Assume 1.5” storage within green roof media and no ponding.
  - o Additional storage for roof runoff is provided by adjacent BMPs.

BMPs – Remainder of Site (Existing Development)

- One (1) 10,600 S.F. bioswale with yard inlet
  - o Capture runoff from existing roadway to improve water quality.
  - o Assume 6” surface storage and 6” subsurface storage area provided.
  - o Bioswale is 820’ long and 13” wide.
  - o Can also provide conveyance for larger storms.
- Tree box filters provide water quality improvements for existing parking areas in eastern section.

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