Low Impact Development

“A Comprehensive Innovative Stormwater Management Technology to Protect Both Aquatic Living Resources and Water Resources”

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Low Impact Development Technology

Overview

- **New Philosophy**
  - Ecologically Functional Design (Mimic Nature)
  - Decentralized Source Control

- **New Principles**
  - Terrestrial and Aquatic Ecosystem Linkages and Processes

- **New Practices**
  - Decentralized / Multi-functional / Multi-beneficial

- **New Process**
  - Conserve / Minimize / Maintain / Integrate / Prevent
Centralized Pipe and Pond Control

Conventional Development

Collect

Convey

Concentrate

Centralized Treatment
LID Development

Multiple Systems

Conservation
Minimization
Open Drainage
Rain Gardens
Rain Barrels
Amended Soils
Pollution Prevention

Distributed
Disconnected
Decentralized
Conventional

Good Drainage

Low Impact

Functional Landscape Design
Limitations of Conventional Stormwater Approaches

- **Economics**
  - Cost of Maintaining a Growing / Aging Infrastructure

- **New Objectives (Public Health / Ecological)**
  - Source Water, CSO’s, Living Resources / Streams
  - Regulations
    - NPDES / TMDL’s / ESA
Issues
West Nile Virus
Safety
Maintenance
Limitations of Conventional Stormwater Approaches

- Technology Gaps
  - Not an anti-degradation strategy
  - Allows hydrodynamic modifications
  - Allows continued stream degradation
  - Allows cumulative impacts
  - Limited use for urban retrofit
  - Unsustainable maintenance burdens
Ecosystem Protection

Protecting or restoring the natural functions, structures, and species composition of an ecosystem, recognizing that all components are interrelated. -- U.S. Fish and Wildlife Service

Apply ecology, science and engineering to ensure homeostasis between the terrestrial and aquatic ecosystems for long-term sustainability.
Natural Conditions

Typical Annual Water Budget

Forest Land Cover

- Interflow: 25.7%
- Groundwater: 36.6%
- Evaporation-Transpiration: 37.4%
- Surface Runoff: 0.3%
Developed Conditions

Typical Annual Water Budget

Urbanized Land Cover

- 25% Evaporation-Transpiration
- 30% Surface Runoff
- 30% Interflow
- 15% Groundwater

May, U of W
The Problem: Conventional Site Design

Collect
Concentrate
Convey
Centralized
Control

Good Drainage Paradigm
Hydrologically Connected

Ecologically Dysfunctional
Conventional Pipe and Pond Centralized Control

“Efficiency”
Compacted Dysfunctional Soils

Figure 3. How soil moisture affects soil compaction. The lines in the soil under the tire represent curves of equal pressure. In all three situations the tire size was 11 x 28, the load was 1,650 pounds and the pressure 12 psi. On wet soil, pressures were transmitted to depths of more than 24 inches. (Source—Soehne, Jour. of Agr. Eng., May 1958.)
Soil Ecosystem Functions
Physical / Chemical / Biological

1. Hydrology
   storage / evaporation / recharge / detention

2. Storing Cycling Nutrients (bacteria / fungi)
   phosphorous / nitrogen / carbon

3. Plant Productivity (vigor)

4. Water Quality
   filter / buffer / degrade / immobilize
   detoxify organic and inorganic materials

“Most diverse ecosystem in the world”
Ecological Structure – It’s Alive!

IT’S NOT DIRT

Soil / Plant / Microbe Complex
A Dynamic Living Ecosystem Cycling Nutrients, Chemicals Water and Energy

Synergistic Relationship
Plants / Bacteria / Protozoa Fungus / Worms* / insects / Mammals
The Importance of Ecological Structure
Impact
Reduction
or
Functional
Restoration

Ecological Integrity
Protection

- Species – Fauna / Flora
- Structure – Spatial / Temp / Distribution
- Processes – Cycling (Energy / Nutrients)

Ecological Factors

1. Hydrology / Hydraulics
2. Habitat Structure
3. Water Quality
4. Energy Sources
5. Biotic Interactions
How well do we maintain the ecological integrity (functions) of aquatic systems (small streams)?

**Scale / Spatial / Temporal / Species**

**Chemical Variables**
- Nutrients
- Temperature
- D.O.
- pH
- Turbidity
- Organics
- Toxics

**Flow Regime**
- Velocity
- Frequency
- Runoff
- Evaporation
- Ground Water
- Flow Duration
- Rain Intensity

**Ecosystem Integrity**

**Habitat Structure**
- Canopy
- Siltation
- Gradient
- Substrate
- Current
- Instream Cover
- Sinuosity
- Width/Depth
- Channel
- Morphology Soils
- Stability
- Riparian Vegetation

**Energy Sources**
- Sunlight
- Nutrients
- Seasonal Cycles
- Organic Matter
- 1&2 Production

**Biotic Factors**
- Disease
- Reproduction
- Feeding
- Predation
- Competition

**Scale / Spatial / Temporal / Species**

**Morphology Soils**
- Stability
- Riparian Vegetation
Environmental Management
Ecological Risk Assessment

Early Warning

Time scale
Years
Months
Days/weeks
Hours/days
Minutes

Sensitivity

Ecological Relevance

Community
Population structure
Growth

Reproduction
Histopathological
Immunological

Physiological
Biochemical
Biomolecular

SUB-ORGANISMAL
INDIVIDUAL
POPULATION--COMMUNITY

Multiple Stressors

Oak Ridge National Laboratory
Imperviousness & Threshold Theories

It’s not so simple - very complex!

Source: Schueler and Claytor, 1995

Level of Stream Quality

Watershed Impervious Cover

- Good (0%)
- Fair (0-10%)
- Low (11-25%)

Non supporting (>25%)
Impacted (11 to 25%)
Sensitive (0 to 10%)
Urbanization Causes a Cumulative Loss of Terrestrial Ecological Functions Vital to the Protection of Aquatic Ecosystems.

Hydrologically and Ecologically Dysfunctional

Hydro-illogical
It’s not **what** but **how** you do it!

- Hydrologically Functional Designs
- Increasing Assimilative Capacity
- Multifunctional / Beneficial Landscape and Architecture

**LID Provides Powerful New Tools to Restore Terrestrial Ecological**
“Technology can be a common ground for agreement by all parties if it does not increase costs and meets resource protection goals”

LID Technology is Supported by both the National Association of Home Builders and the Natural Resources Defense Council
How Does LID Maintain or Restore The Hydrologic Regime?

- Creative ways to:
  - Maintain / Restore Storage Volume
    - interception, depression, channel
  - Maintain / Restore Infiltration Volume
  - Maintain / Restore Evaporation Volume
  - Maintain / Restore Runoff Volume
  - Maintain Flow Paths
- Engineer a site to mimic the natural water cycle functions / relationships
LID Basics

- Principles
- Practices
- Process
Key LID Principles “Volume”

“Hydrology as the Organizing Principle ”

- Unique Watershed Design
  - Match Initial Abstraction Volume
  - Mimic Water Balance

- Uniform Distribution of Small-scale Controls

- Cumulative Impacts of Multiple Systems
  - filter / detain / retain / use / recharge / evaporate

- Decentralized / Disconnection

- Multifunctional Multipurpose Landscaping & Architecture

- Prevention
Defining LID Technology

Major Components

1. Conservation (Watershed and Site Level)
2. Minimization (Site Level)
3. Strategic Timing (Watershed and Site Level)
4. Integrated Management Practices (Site Level)
   Retain / Detain / Filter / Recharge / Use
5. Pollution Prevention

Traditional Approaches
1. Conservation Plans / Regulations

- Local Watershed and Conservation Plans
  - Forest (Contiguous and Interior Habitat)
  - Streams (Corridors)
  - Soils
  - Recharge Areas
  - Wetlands
  - Habitats
  - Step Slopes
  - Buffers
  - Critical Areas
  - Parks
  - Scenic Areas
  - Trails
2. Minimize Impacts

- Minimize clearing
- Minimize grading
- Save A and B soils
- Limit lot disturbance
- Alternative Surfaces
- Reforestation
- Disconnect
- Reduce pipes, curb and gutters
- Reduce impervious surfaces

![Diagram showing Low Impact Design and Multifunctional Use of Landscape and Infrastructure]
3. Maintain Time of Concentration

- Open Drainage
- Use green space
- Flatten slopes
- Disperse drainage
- Lengthen flow paths
- Save headwater areas
- Vegetative swales
- Maintain natural flow paths
- Increase distance from streams
- Maximize sheet flow
4. Storage, Detention & Filtration

“LID IMP’s”

- Uniform Distribution of Source Controls
  - Open drainage swales
  - Rain Gardens / Bioretention
  - Smaller pipes and culverts
  - Small inlets
  - Depression storage
  - Infiltration
  - Rooftop storage
  - Pipe storage
  - Street storage
  - Rain Water Use
  - Soil Amendments*
5. Pollution Prevention

30 - 40% Reduction in N&P
Kettering Demonstration Project

- Maintenance
- Proper use, handling and disposal
  - Individuals
    - Lawn / car / hazardous wastes / reporting / recycling
  - Industry
    - Good house keeping / proper disposal / reuse / spills
  - Business
    - Alternative products / Product liability
LID Site
Control at the Source

Conservation
Porous Pavement
Open Drainage
Create a Hydrologically Functional Lot

Amended Soils
Rain Gardens
Rain Barrel
Narrower Streets
LID rebuilds ecological functions piece by piece.

Cumulative Beneficial Impacts of LID Techniques
Multiple Systems

Disconnected
Decentralized
Distributed

LID Development
Rain Gardens

Typical Landscape Maintenance Practices
Rain Garden

Treatment Train Approach

Bioretention Cell

Storm Drain System

Flow Path

Grass Swale

Grass Filter Strip
VIEW OF LOT WITH STORAGE AND BIORETENTION
Rain is Resource

Capture & Use

Toilet Flushing
Car washing
Irrigation
Mixing / Washing
Gardening
Recharge

Benefits

Reduce Demand
Self-sufficiency
Save Money
Did You Know:

Kettering residents discharge approximately 1,277 quarts of detergents each year to the local stream from car washing alone.

Approximately 2,533 quarts of oil are disposed of improperly in Kettering each year and have the potential to contaminate the stream.

Approximately 2,992 quarts of antifreeze are drained onto the streets of Kettering where it then runs directly into the stream.

Approximately 23,643 pounds of nitrogen have the potential of being washed off of Kettering lawns each year from fertilizer applications.

Approximately 80% of Kettering residents apply some form of chemical pesticides to their yards each year.

When our environmental education program began last summer, 58% of Kettering residents did not know that neighborhoods like Kettering cause water pollution.

The stream that flows through the eastern part of Kettering into the Northeast Branch is so polluted that it can support almost no aquatic life.
LID Practices (No Limit!)

“Creative Techniques to Treat, Use, Store, Retain, Detain and Recharge”

- Bioretention / Rain Gardens*
- Strategic Grading*
- Site Finger Printing
- Conservation*
- Flatter Wider Swales
- Amended Soils*
- Long Flow Paths
- Tree / Shrub Depression
- Turf Depression
- Landscape Island Storage
- Rooftop Detention / Retention
- Disconnection*
- Parking Lot / Street Storage
- Smaller Culverts, Pipes & Inlets
- Alternative Surfaces
- Reduce Impervious Surface
- Surface Roughness Technology
- Rain Barrels / Cisterns / Water Use*
- Catch Basins / Seepage Pits
- Sidewalk Storage
- Vegetative Swales, Buffers & Strips*
- Infiltration Swales & Trenches
- Eliminate Curb and Gutter
- Shoulder Vegetation
- Maximize Sheet flow
- Maintain Drainage Patterns
- Reforestation..................
- Pollution Prevention.............
Rain Gardens
Rain Garden

Treatment Train Approach

- Bioretention Cell
- Flow Path
- Grass Swale
- Grass Filter Strip
- Storm Drain System
Discharge Comparison

Monitoring Results

Time, April 6, 2001

Discharge, cfs/acre

LID Q
Conv. Q
How Does Your Garden Grow?

A Reference Guide to Enhancing your Rain Garden
## Construction Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Low Impact</th>
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</thead>
<tbody>
<tr>
<td><strong>Grading/Roads</strong></td>
<td>$569,698</td>
<td>$426,575</td>
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<tr>
<td><strong>Storm Drains</strong></td>
<td>$225,721</td>
<td>$132,558</td>
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<tr>
<td><strong>SWM Pond/Fees</strong></td>
<td>$260,858</td>
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<tr>
<td><strong>Bioretention/Micro</strong></td>
<td>—</td>
<td>$175,000</td>
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<tr>
<td><strong>Total</strong></td>
<td>$1,086,277</td>
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<tr>
<td><strong>Unit Cost</strong></td>
<td>$14,679</td>
<td>$9,193</td>
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<tr>
<td><strong>Lot Yield</strong></td>
<td>74</td>
<td>81</td>
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Low-Impact Development
Hydrologic Analysis and Design

- Based on NRCS technology, can be applied nationally
- Analysis components use same methods as NRCS
- Designed to meet both storm water quality and quantity requirements
Hydrograph Pre/Post Development

- Developed Condition, Conventional CN
  (Higher Peak, More Volume, and Earlier Peak Time)

- Existing Condition
Hydrographs Summary

1. Existing
2. Developed, conventional CN, no control.
3. Developed, conventional CN and control.
4. Developed, LID-CN, no control.
5. Developed, LID-CN, same Tc.
6. Developed, LID-CN, same Tc, same CN with retention.
7. Same as 5, with additional detention to maintain Qp.

Pre-development Peak Runoff Rate

Q

T
## LID Techniques and Objectives

### Low-Impact Development Technique

<table>
<thead>
<tr>
<th>Low Impact Development Objective</th>
<th>Flatten Slope</th>
<th>Increase Flow Path</th>
<th>Increase Sheet Flow</th>
<th>Increase Roughness</th>
<th>Minimize Disturbance</th>
<th>Larger Swales</th>
<th>Flatten Slopes on Swales</th>
<th>Infiltration Swales</th>
<th>Vegetative Filter Strips</th>
<th>Constricted Pipes</th>
<th>Disconnected Impervious Areas</th>
<th>Reduce Curb and Gutter</th>
<th>Rain Barrels</th>
<th>Rooftop Storage</th>
<th>Bioretention</th>
<th>Re-Vegetation</th>
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<td>Increase Detention Time</td>
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<td>Increase Storage</td>
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<td>Lower Post Development CN</td>
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Summary of LID Techniques

(1) Recalculate Postdevelopment CN based on LID land use and impervious surface disconnection.

(2) Increase Travel Time (TT) using LID techniques to achieve the same Tc as Existing conditions.

(3) Retention: Provide permanent storage (Infiltration/Retention) using LID techniques to maintain the CN and runoff volume of existing conditions.

(4) Detention: Provide additional detention storage to maintain the same peak discharge as existing conditions.