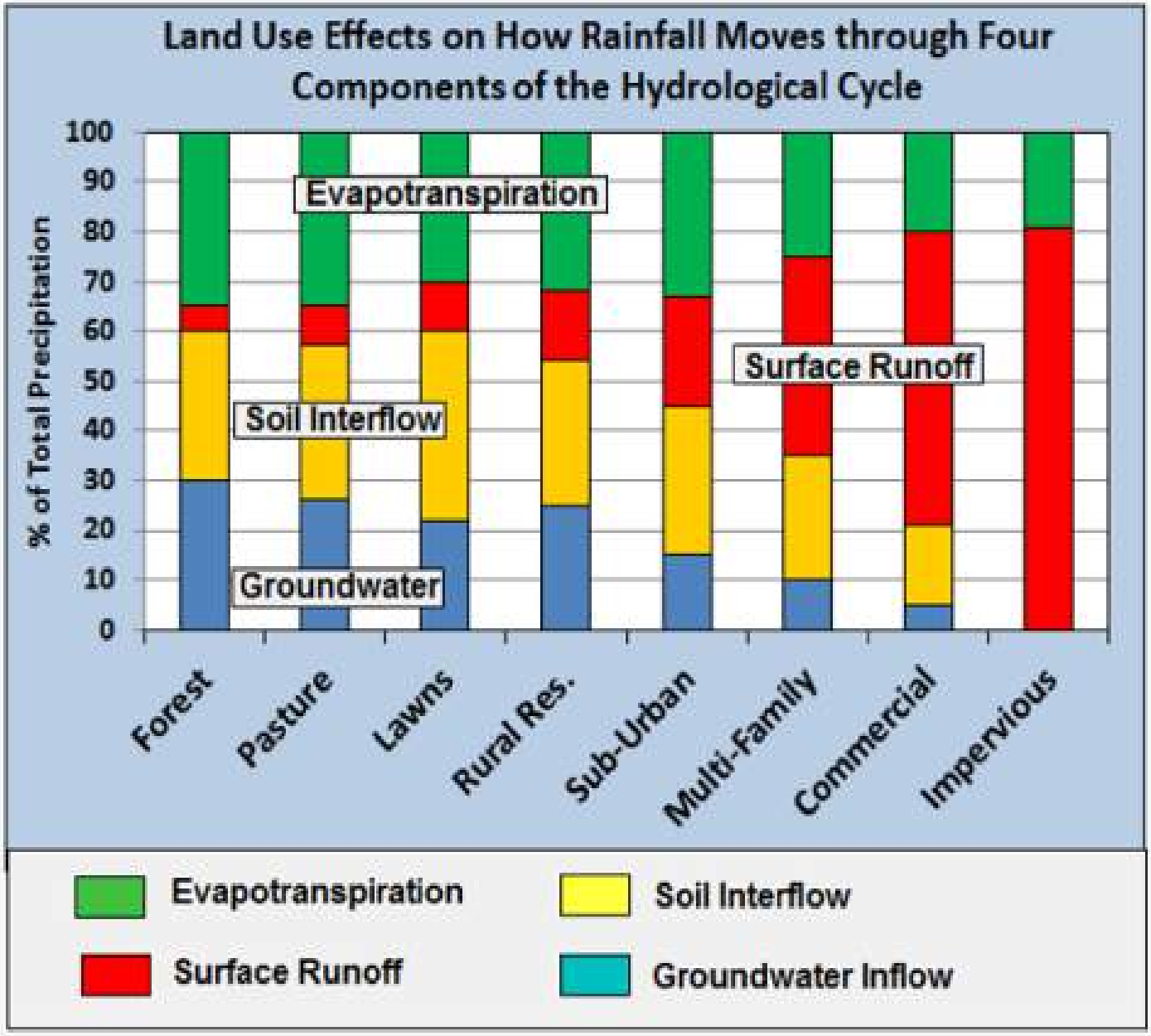
Urban Stormwater Management


Land Use Effects on How Rainfall Moves through Four Components of the Hydrological Cycle
% of Total Precipitation
100
90
80
70
60
50
40
30
20
10
0
Evapotranspiration
Soil Interflow
Groundwater
Surface Runoff
Forest
Pasture
Lawns
Rural Res.
Sub-Urban
Multi-Family
Commercial
Impervious
Evapotranspiration
Soil Interflow
Surface Runoff
Groundwater Inflow

Impervious Surfaces and Conveyance Systems = Increases Pollution

Typical Non-Point Sources of Pollution (NPS)

Deposition of atmospheric pollutants (NOx, SOx)

Nutrient & Pesticides from applications to lawns, golf courses, right-of-ways

Land clearing and construction activities

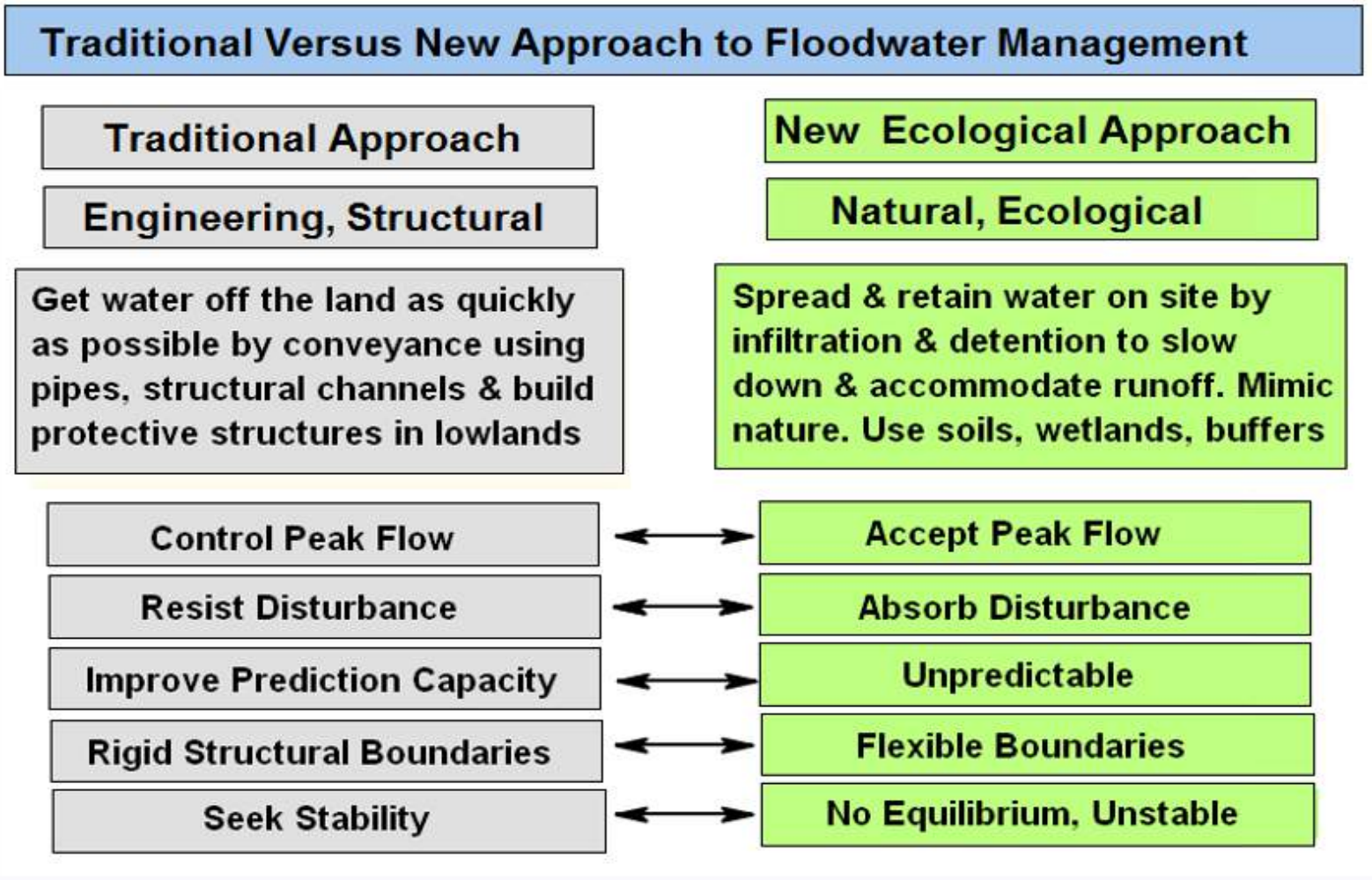
Accidental spills and illegal dumping of waste

Vehicle traffic, wear and tear exhaust fumes and leaks in parking lots

Organic Materials and pathogens from animal wastes (pets & wildlife)

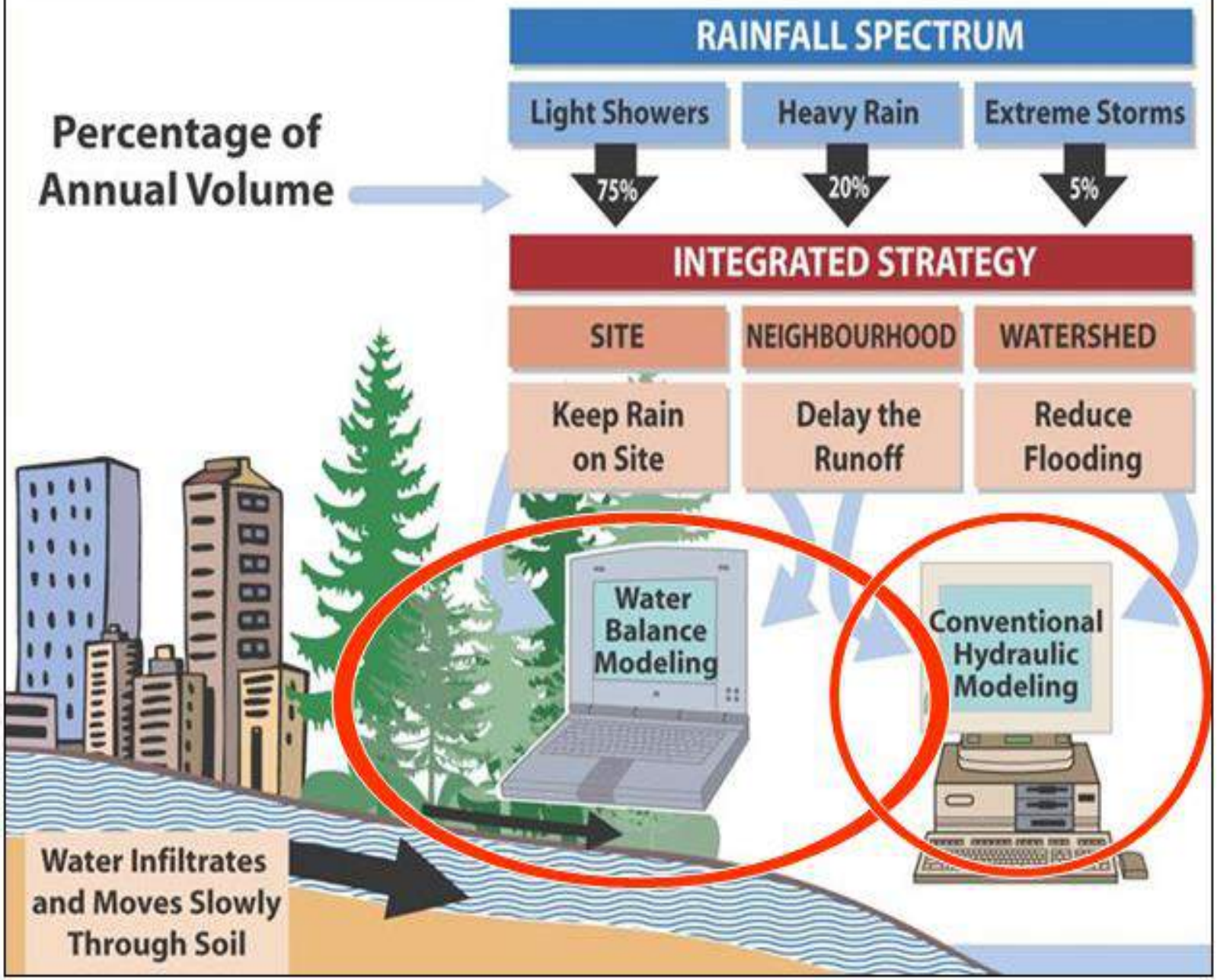
Combined sewers and septic systems discharges

Commercial and Industrial runoff and discharge


Traditional Versus New Approach to Floodwater Management
Traditional Approach
New Ecological Approach
Engineering, Structural
Natural, Ecological
Get water off the land as quickly as possible by conveyance using pipes, structural channels & build protective structures in lowlands
Spread & retain water on site by infiltration & detention to slow down & accommodate runoff. Mimic nature. Use soils, wetlands, buffers
Control Peak Flow
Accept Peak Flow
Resist Disturbance
Absorb Disturbance
Improve Prediction Capacity
Unpredictable
Rigid Structural Boundaries
Flexible Boundaries
Seek Stability
No Equilibrium, Unstable

Floodwater Management Practices

Traditional Approach	New Ecological Approach
Engineering, Structural	Natural, Ecological
Upstream Quick flow & Conveyance Push high water downstream Stormwater Pipes Streightening Channels Armoring Channels	**Upsteam** Spread & retain water Infiltration and slow release Raingardens, Pervious Pavement Temporary Storage Ponds, Swales Wetlands, Wide Buffers
In Floodplain Structural Engineering Dykes, Levees, Dams Protection Systems Flood Proofing Non-structural: Zoning	**In Floodplain** Recreate Natural Channels Wide Riparian Zone with Wetlands Create Side Channels Designate areas for Temporary Water Storage, Zoning,



www.waterbucket.bc.ca

Urban Stormwater Management

SCALE	TRADITIONAL APPROACH	INNOVATIVE APPROACH
Site (Property)	Drain & Remove (Piping)	Retain Rain on Site
Neighbourhood (Subdivision)	Drain & Remove (Piping)	Store & Delay Runoff
Watershed	Store Runoff (dams) Channalize Flow Protective Structures	Delay & Reduce Floods, Large Buffer Zones & BMP's

Site or Property	Innovations
Keep Rain on Site Detention & Infiltration Focus on Light Rain	Green Roof Roofwater Harvesting and Re-Use Minimize Impervious Surfaces Pervious Pavement 30 cm Topsoil Requirements Encourage Urban Tree Planting

Neighborhood Scale	Innovations
Delay Runoff Detention & Filtration Focus on Heavy Rain	Smaller Roads (no Curbs & Gutters) Swales for Road Runoff Detention Ponds (Wetlands) Pervious Pavement Innovatice Parking Lots

Watershed Scale	Innovations
Minimize Floods Detain, Devert and Temporate Storage	Lange Buffer Zones Diversify Stream Channel Pervious Pavement Land Use Zoning Floodplain Management

Site (Property) Scale : Green Roofs

- Green Roofs
- Rain Harvesting
- Imperviousness

Rain Falling on Roof

Tradition

Traditionally Rainwater is directed from the roof into stormwater pipes

Innovations

1. Green Roofs retain and slowly relace runoff

2. Roofwater is infiltrated into Swales and Soils

3. Roofwater is harvested for outdoor use in gardens

5. Roofwater is harvested for indoor use

Site: Roofwater Harvesting

Tradition

Roofwater into Stormwater Drain

- Green Roofs
- Rain Harvesting
- Imperviousness

Outdoor Water Use

Between 30% - 50% of Domestic Water is Used for Watering Lawns
Roofwater Harvesting can reduce this demand by at least 50%

Roofwater Harvesting for :
Domestic and Outdoor Water Use

Traditionally Paved Driveways

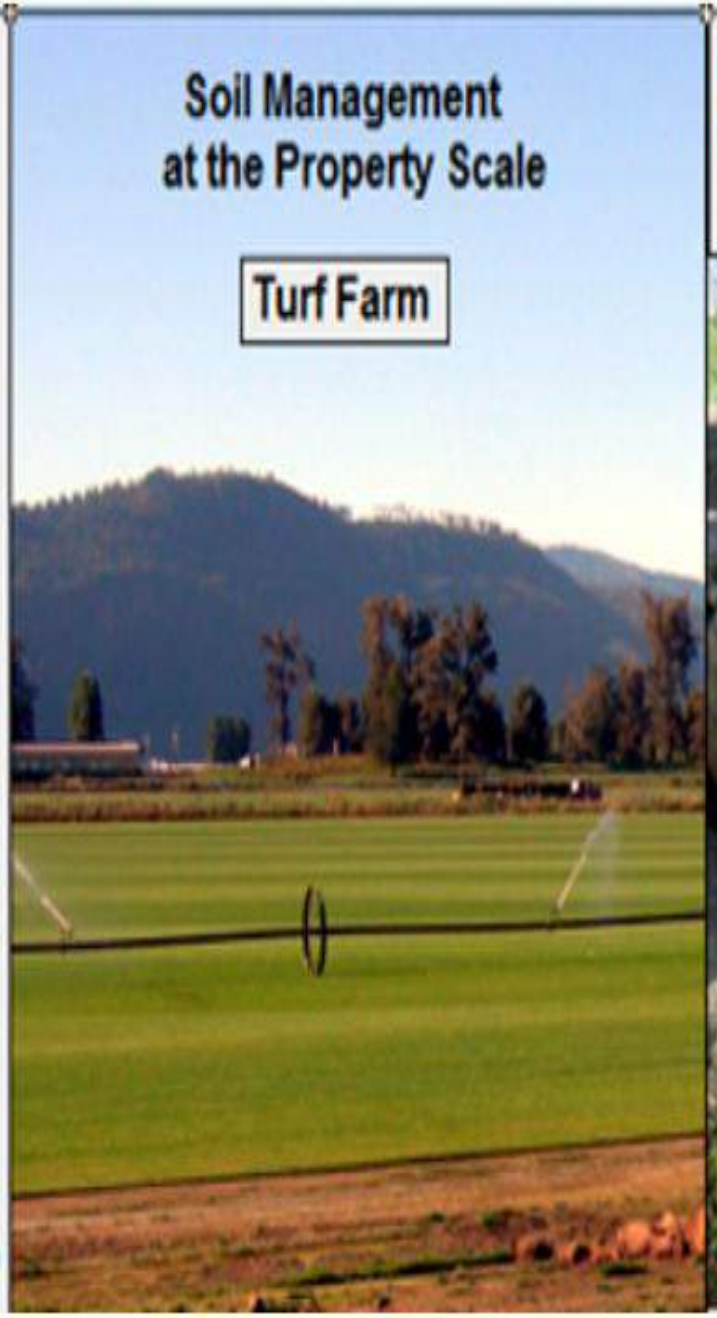
Site (Property) Scale : Minimizing Imperviousness

Managing Lawns & Xeriscaping

Traditional Approach:
Remove Soil before house construction
Compact remaining soil during construction
Add turf before new house is completed

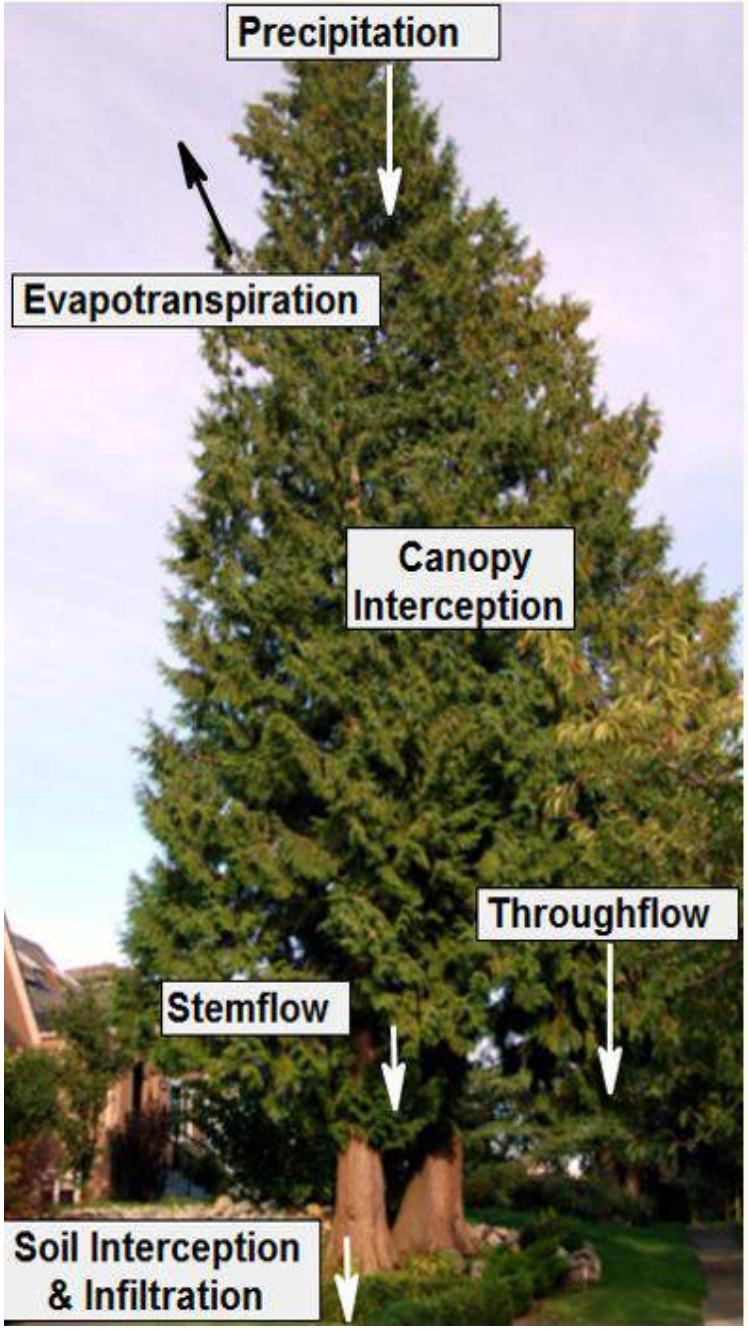
Innovative Approach:

Adding 30-50cm of topsoil before adding turf can reduce irrigation water requirements by 30% and allows large amount of rainfall to be stored in the soil
(Green Water Management)



Problem: Turf with 5-10 cm of soil
Requires addition of 30-50cm of topsoil before laying the turf !

30 cm Topsoil Requirements can reduce the irrigation requirements by at least 30%



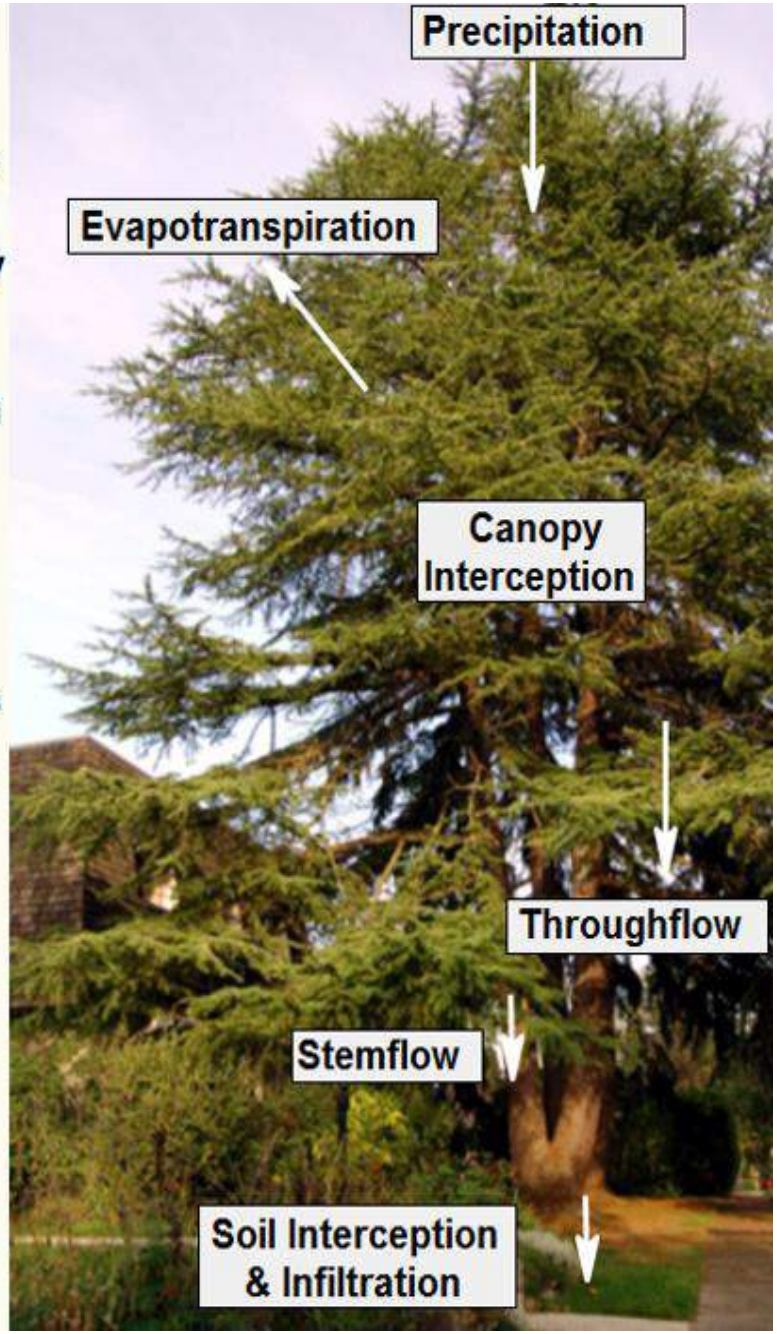
Urban Trees

Trees are effective in reducing runoff from your property

by evapotranspiration and by delaying runoff and Infiltration

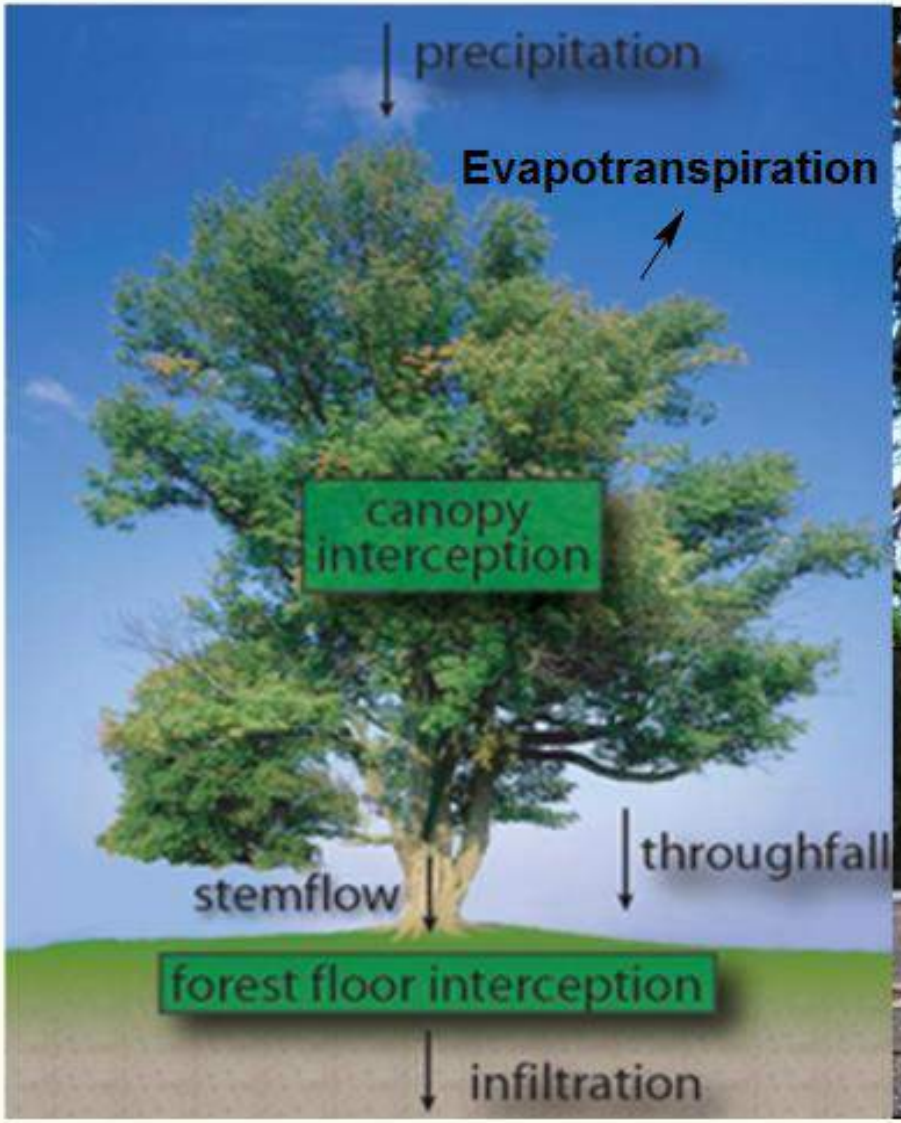
Additional Benefits
CO_2 absorption

ProvidesCooler Temperatures During Hot Summers



THE ROLE OF TREES IN URBAN STORMWATER MANAGEMENT

Measuring rain interception by urban trees

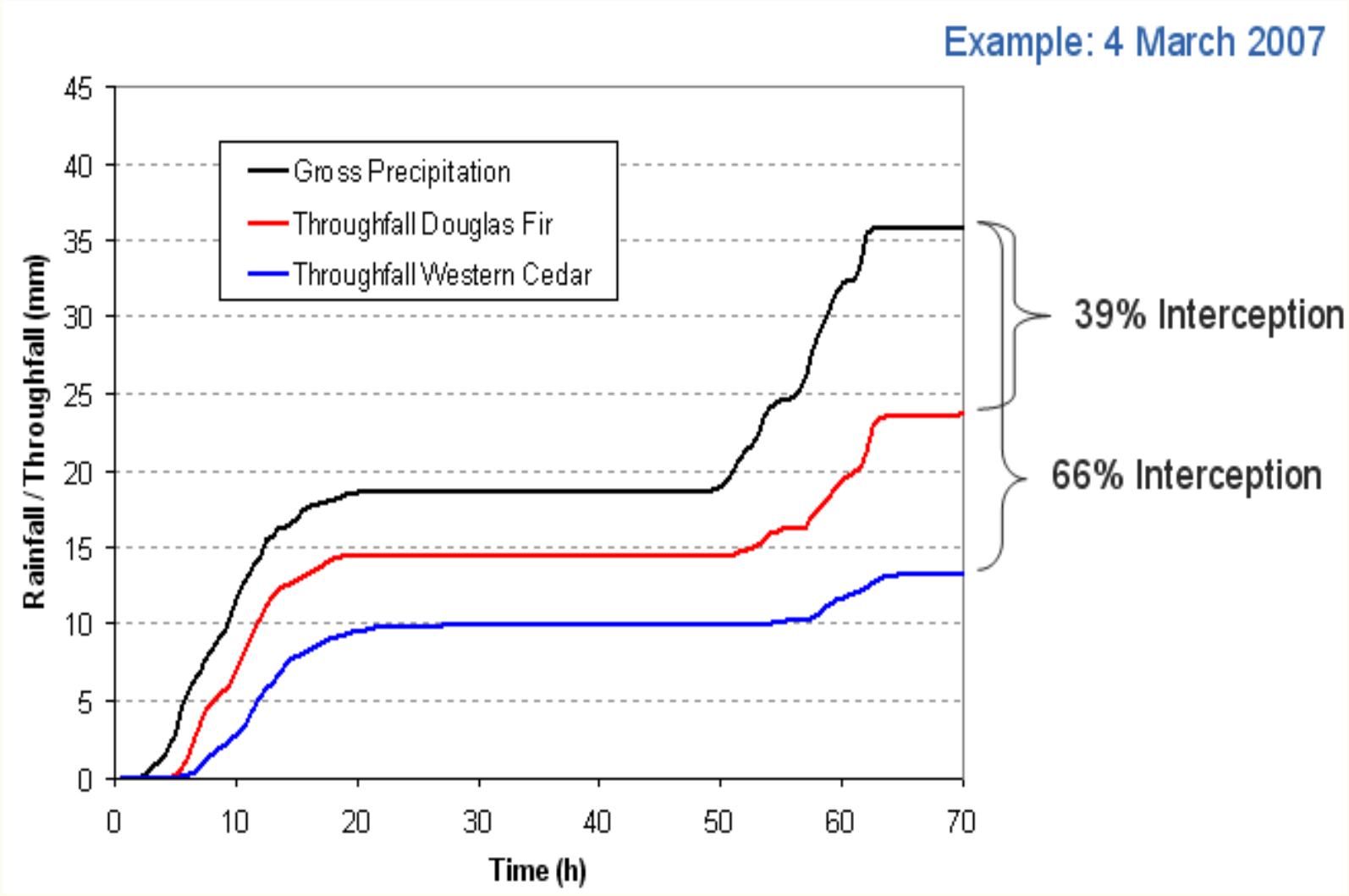


Trees in forests intercept and evapotranspire about 25-35% of the Rainfall
Urban trees have a much higher rate of interception & evapotranspiration

Results from Urban Tree Interception Study

Data Analysis - Total interception

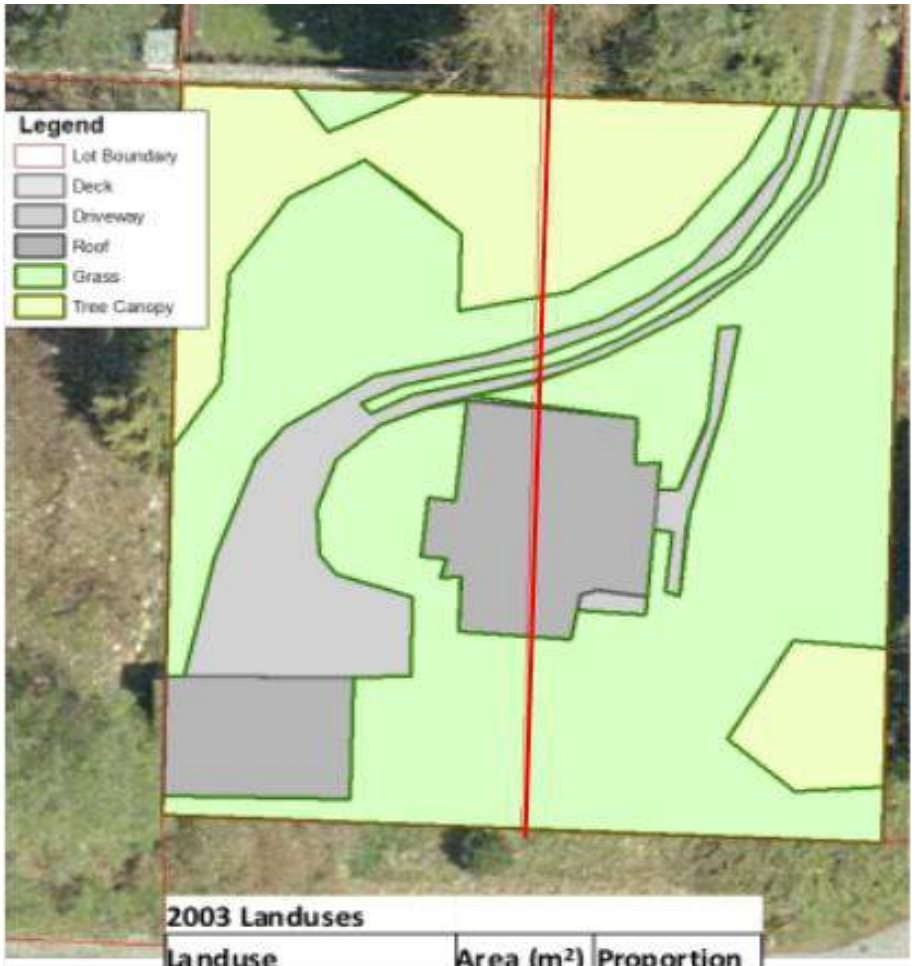
Source: Weiler 2007



Snow Interception by Urban Trees


2003


2009



2003 Landuses

Landuse	Area (m^2)	Proportion
Driveway	186	11%
Roof	207	12%
Grass	961	57%
Tree Canopy	339	20%
Impervious	393	**23%**
Pervious	1300	**77%**

2003 Imperviousness 23%

2009 Landuses

Landuse	Area (m^2)	Proportion
Driveway	373	22%
Roof	463	27%
Deck	74	4%
Grass	723	43%
Tree Canopy	65	4%
Impervious	910	**54%**
Pervious	788	**46%**

2009 Imperviousness 54%

Neighborhood Scale	Innovations
Delay Runoff Detention & Filtration Focus on Heavy Rain	Smaller Roads (no Curbs & Gutters) Swales for Road Runoff Detention Ponds (Wetlands) Pervious Pavement Innovatice Parking Lots

Stormwater management

Goal:
60% of rainfall detained in rock pits
30% of rainfall in infiltration galleries and detention ponds
Excessive storms into bypass storm system

CHILLIWACK Promotory Height

Low impact urban stormwater design

Neighborhood Scale	Innovations
Delay Runoff Detention & Filtration Focus on Heavy Rain	Smaller Roads (no Curbs & Gutters) Swales for Road Runoff Detention Ponds (Wetlands) Pervious Pavement Innovative Parking Lots

Neighborhood: Small Roads (no Curbs or Gutters)

Small Roads
Swales
Detention &
Pervious
Parking Lots

Traditional Roads

Traditional Approach to Managing Road Runoff

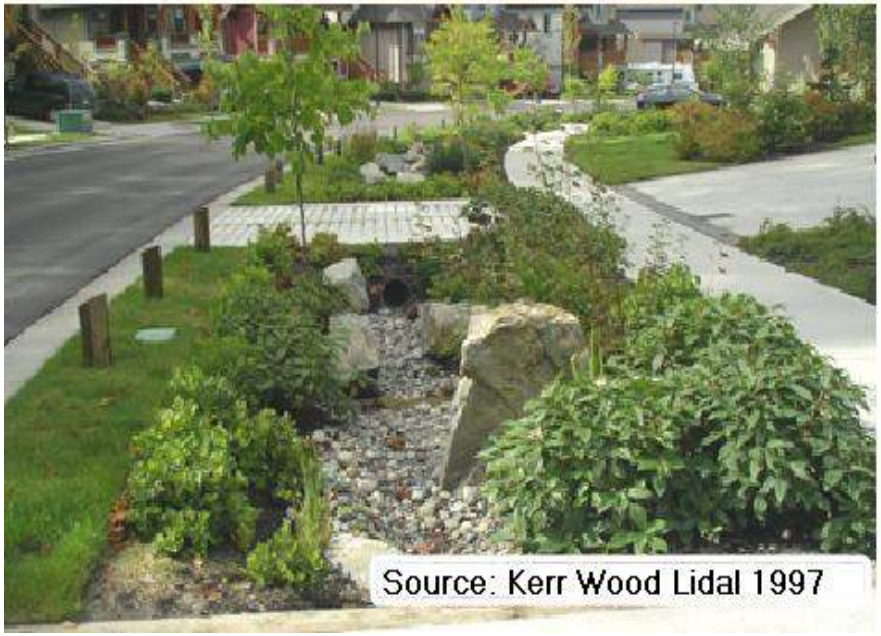
Drain runoff using a stormwater piping system. Conway runoff into urban streams. No considerations is given to dealing with compaminants that accummulate on road surfaces from transport activities

Innovative Roads

No Curbs & Gutters
all runoff is
infiltrated in Swales

Roads are smaller
Less impervious
surfaces

Road Runoff into Swales



Source: Kerr Wood Lidal 1997


2014


Swales

Traditional Parking Lots: Drainage & Contaminants are Conveyed into Urban Streams

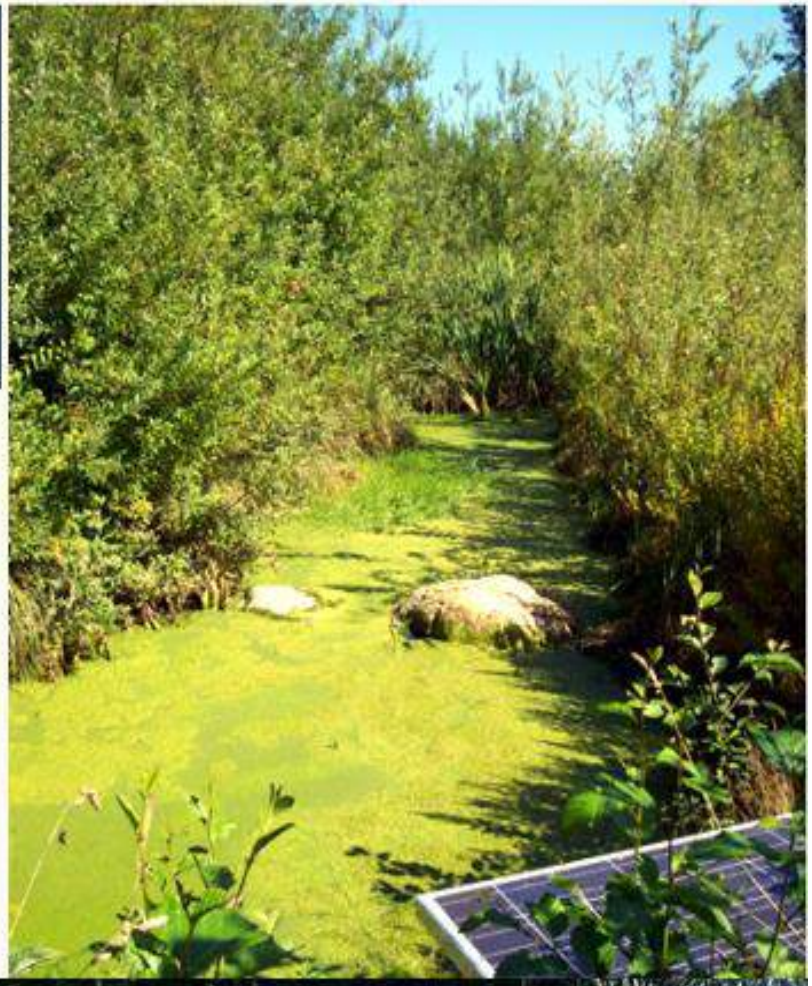
Neighborhoods: Innovative Parking Lots

Catching Parking Lot Run-Off

WETLANDS IN STORMWATER MANAGEMENT

What about the Mosquito Problem ?

1. Prevent the build up of stagnant water
2. Minimize eutrophication
3. Use a wide range of wetland plants (biodiversity)
4. Assure open space between plants
5. Introduce fish as predators
6. Biological control with larvicide



Watersheds: Pervious Pavement

Tradition

- Buffers
- Channels
- Pervious
- Zoning
- Floodplain

Pervious Cement

Innovations

Pervious Pavement

Site or Property	Innovations
Keep Rain on Site Detention & Infiltration Focus on Light Rain	Green Roof Roofwater Harvesting and Re-Use Minimize Impervious Surfaces Pervious Pavement 30 cm Topsoil Requirements Encourage Urban Tree Planting

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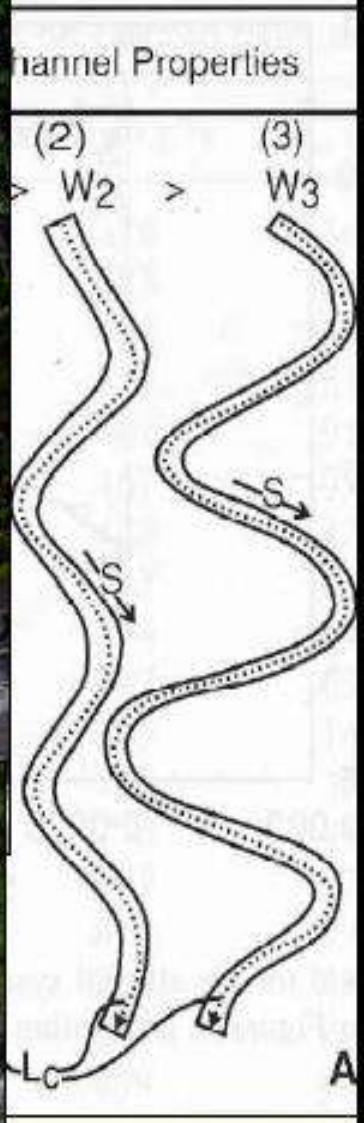
Watershed Scale	Innovations
Minimize Floods Detain, Devert and Temporate Storage	Lange Buffer Zones Diversify Stream Channels Pervious Pavement Land Use Zoning Floodplain Management

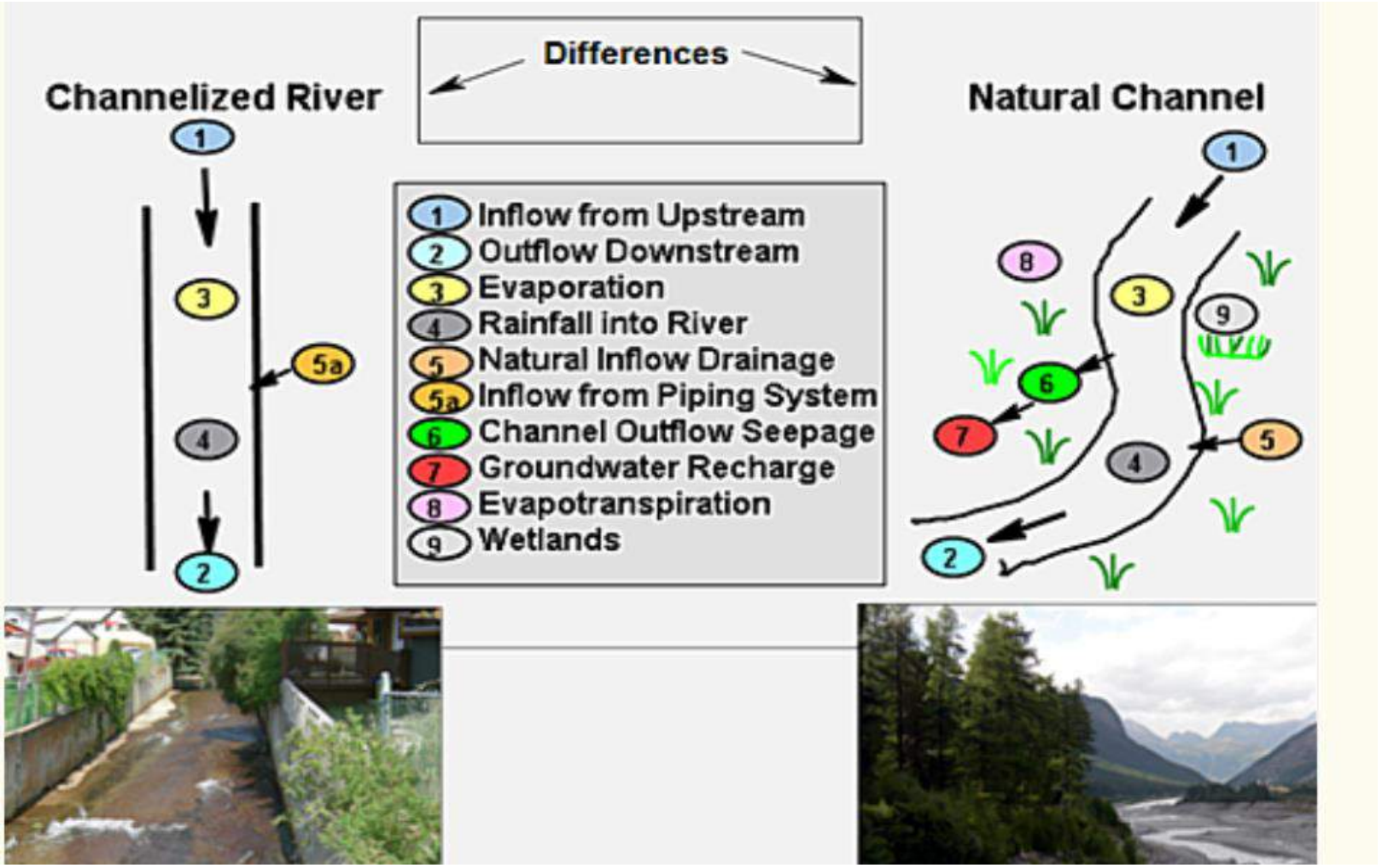
Watersheds: Artificial Channels vs Diversified Channels

Tradition

Innovations

- Buffers
- Channels
- Pervious
- Zoning
- Floodplain



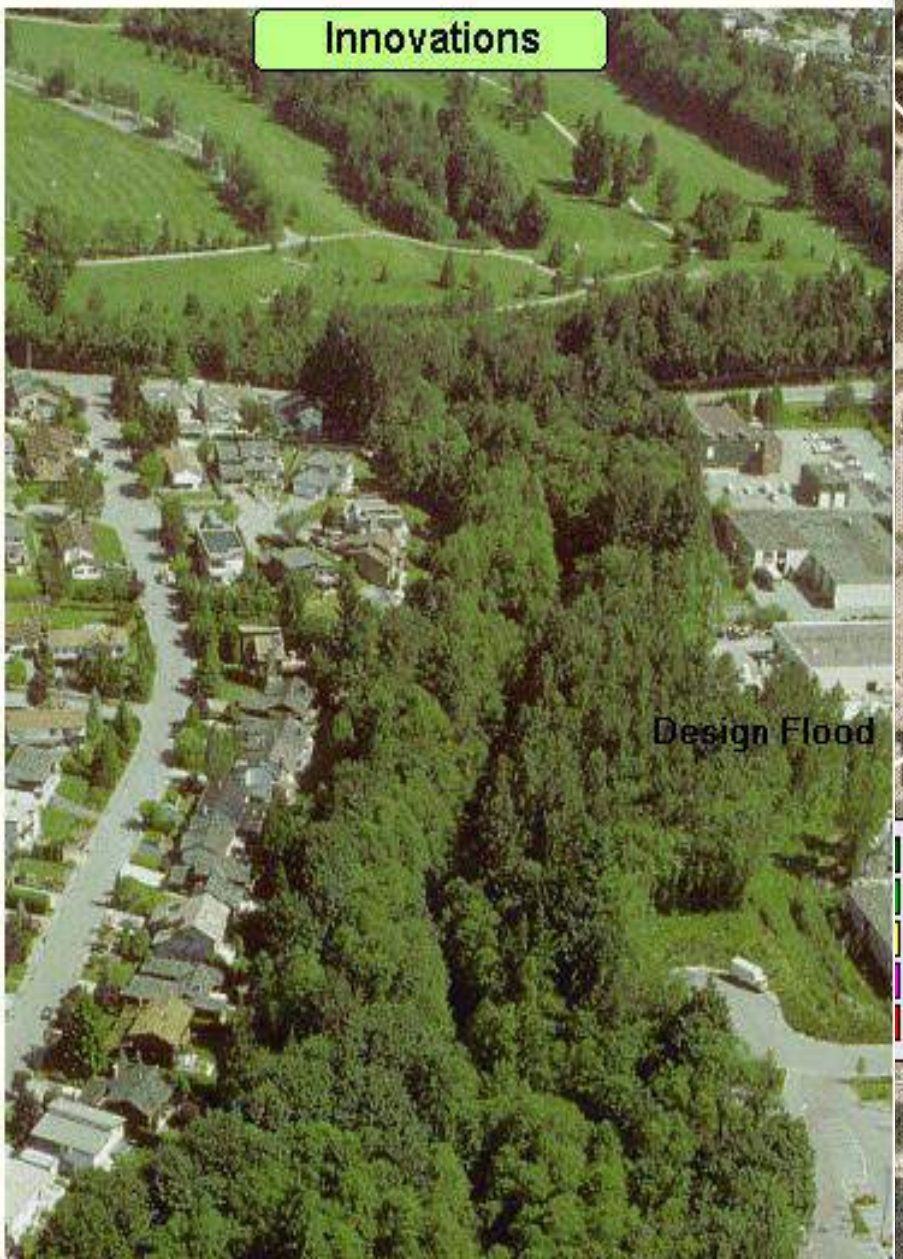

Differences
Channelized River
Natural Channel
1 Inflow from Upstream
2 Outflow Downstream
3 Evaporation
4 Rainfall into River
5 Natural Inflow Drainage
5a Inflow from Piping System
6 Channel Outflow Seepage
7 Groundwater Recharge
8 Evapotranspiration
9 Wetlands

Watersheds: Riparian Buffer Zone

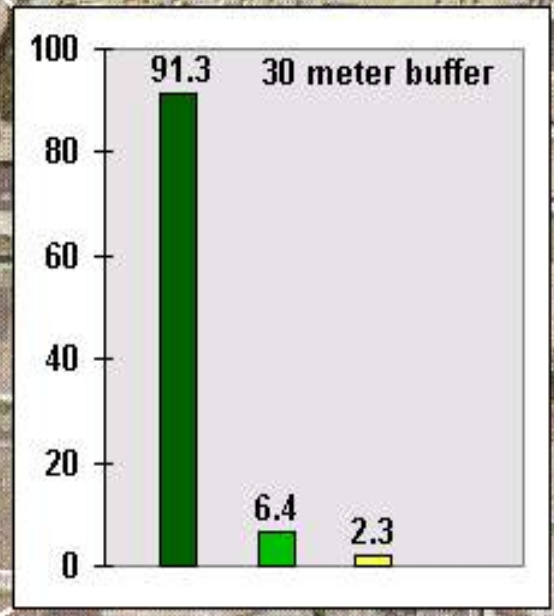
Buffer Zones

sheds: Riparian Buffer Zone

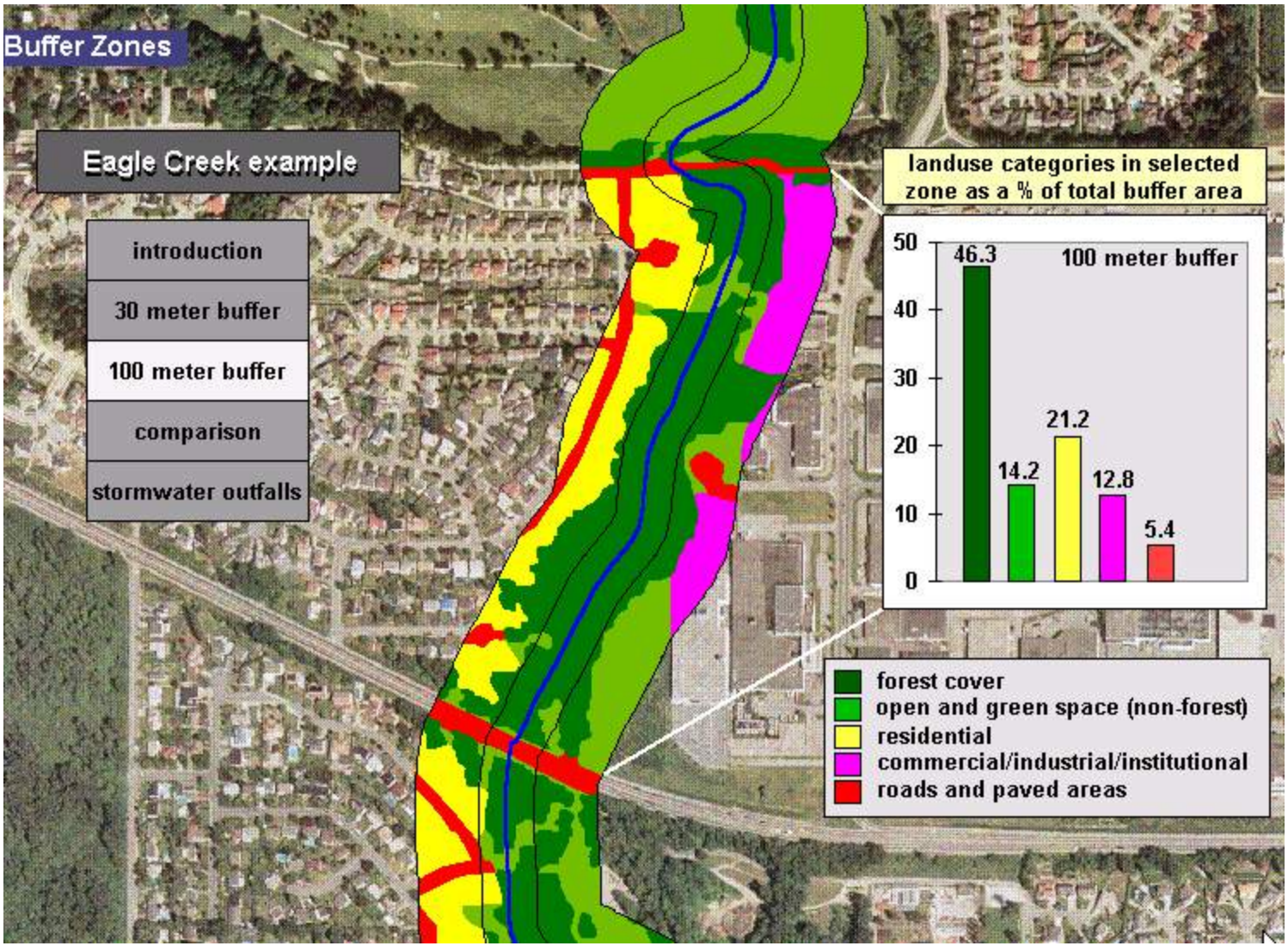
Innovations



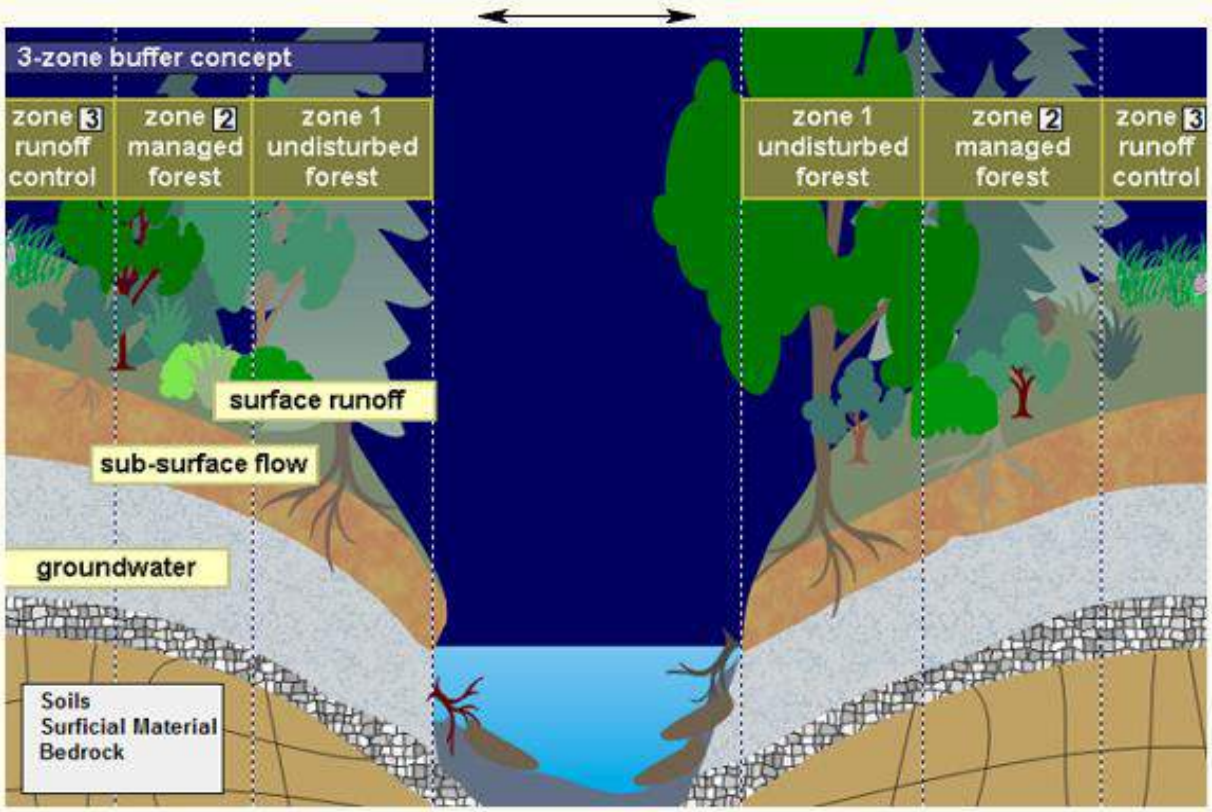
landcover categories in selected zone as a % of total buffer area



- forest cover
- open and green space (non-forest)
- residential
- commercial/industrial/institutional
- roads and paved areas

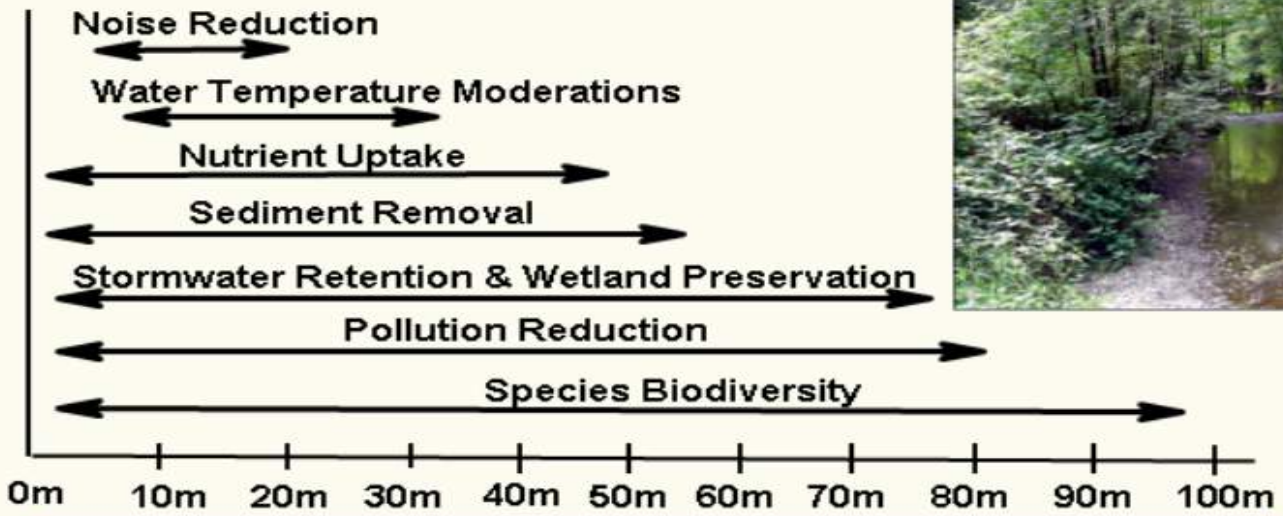

Buffer Zones
Eagle Creek example
introduction
30 meter buffer
100 meter buffer
comparison
stormwater outfalls
landuse categories in selected zone as a % of total buffer area
100 meter buffer
46.3
14.2
21.2
12.8
5.4
50
40
30
20
10
0
forest cover
open and green space (non-forest)
residential
commercial/industrial/institutional
roads and paved areas

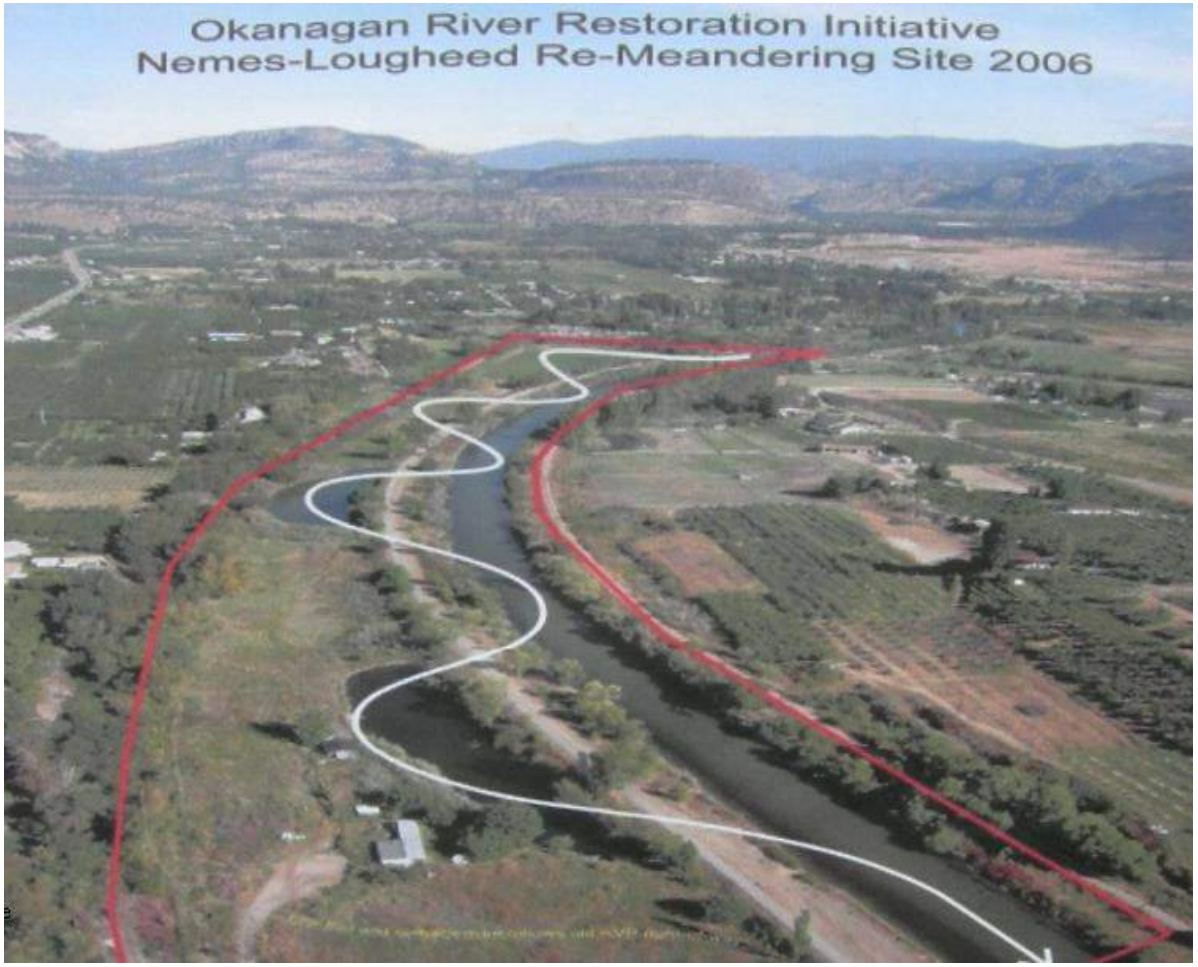
Three Zone Concept that Focuses on: Groundwater, Sub-Surface and Surface Flow



Maintain Large Riparian Buffer Zones to Provide Many Functions:

- Shade & Moderating Water
- Store & Detain
- Provide Organic Matter
- Create Biodiversity
- Reduce Contaminants
- Retain Sediments
- Recreational
- Nutrients Uptake
- Noise Reduction




Okanagan River Restoration Initiative
Nemes-Lougheed Re-Meandering Site 2006


Before Flood

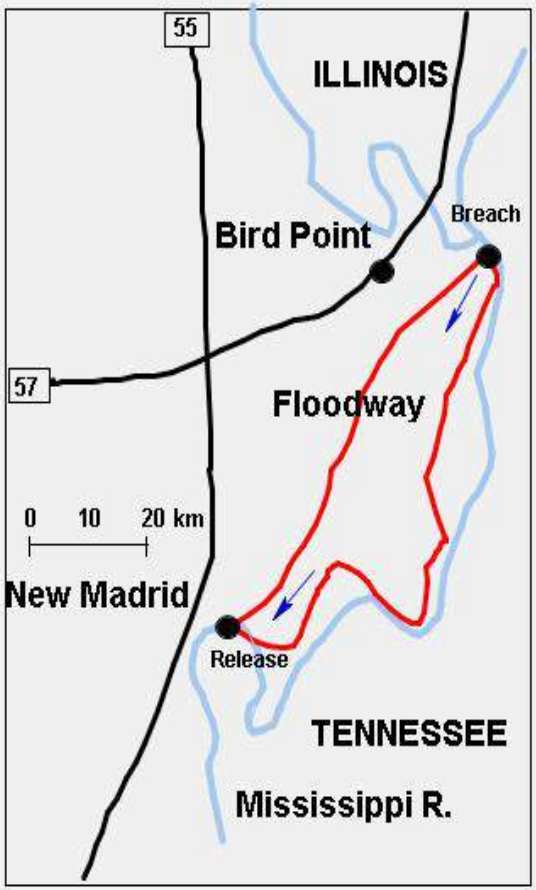

Before Flood

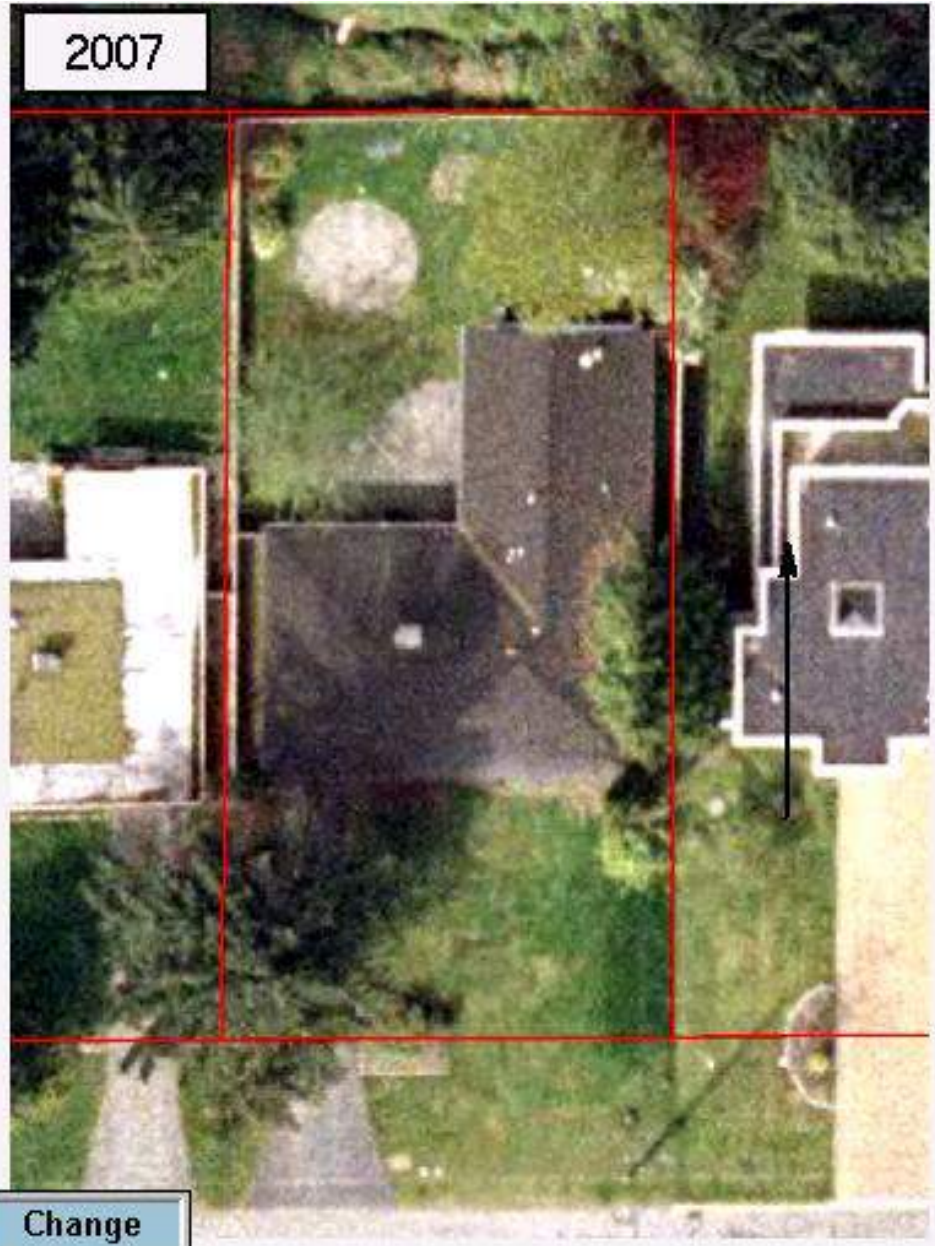

After Flood


After Flood

Building more protective structures is now longer sufficient:
New Approach: Flood Design Designate Areas for Temporary Storage of Flood Water

Mississippi Temporary Flood Water Storage on Agricultural Land (2012)





Change

EIA

Hydrology

Redevelopment : Addition of Suite

Redevelopment with Secondary Suite

2007 Landuses

Landuse	Area (m^2)	Proportion
Driveway	47	6%
Roof	270	35%
Grass	420	54%
Tree Canopy	44	6%
Impervious	317	41%
Pervious	464	59%

2007 Imperviousness 41%

2009 Landuses

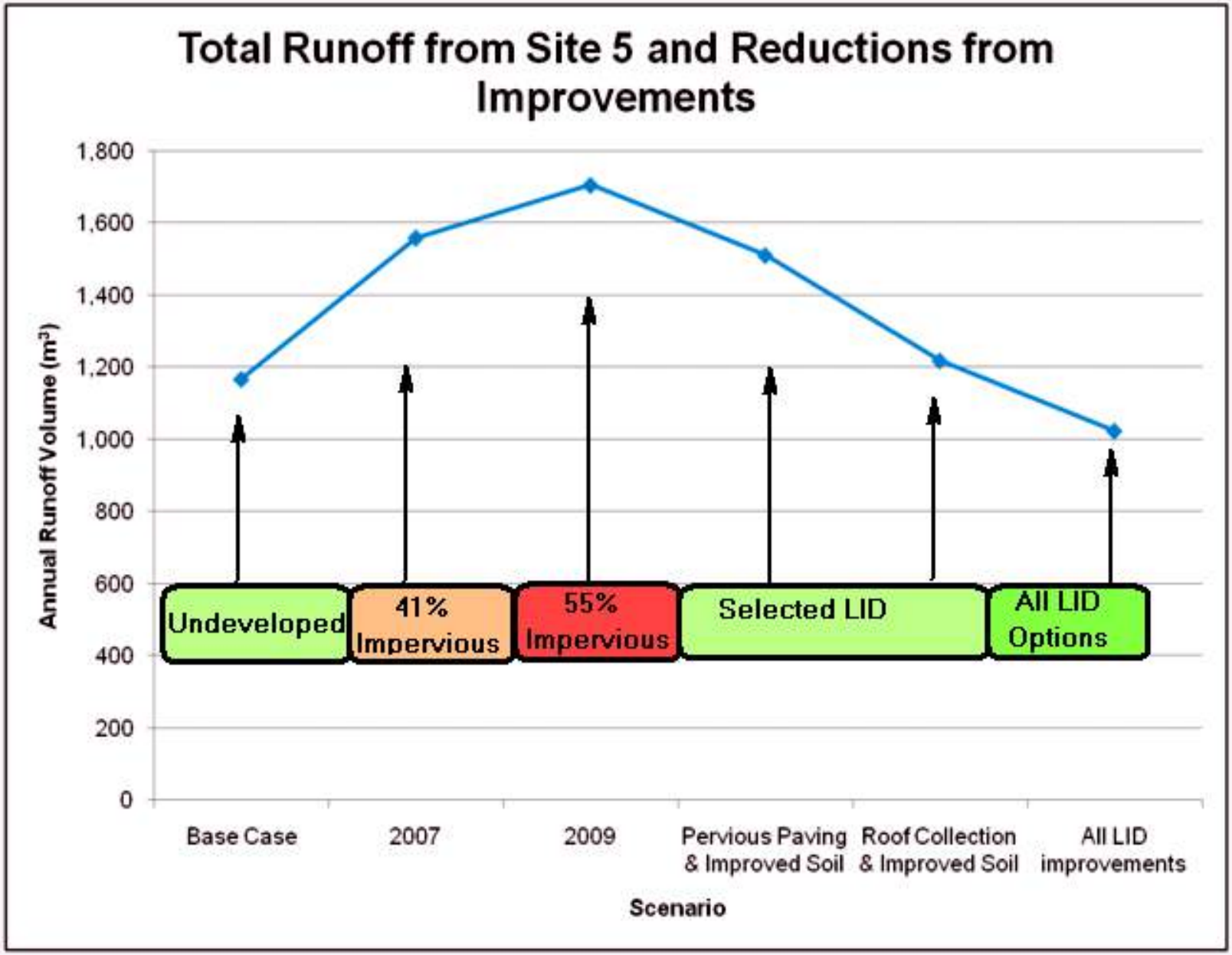
Landuse	Area (m^2)	Proportion
Driveway	55	7%
Roof	291	37%
Deck	80	10%
Grass	344	44%
Tree Canopy	11	1%
Impervious	426	55%
Pervious	355	45%

2009 Imperviousness 55%

Change

EIA

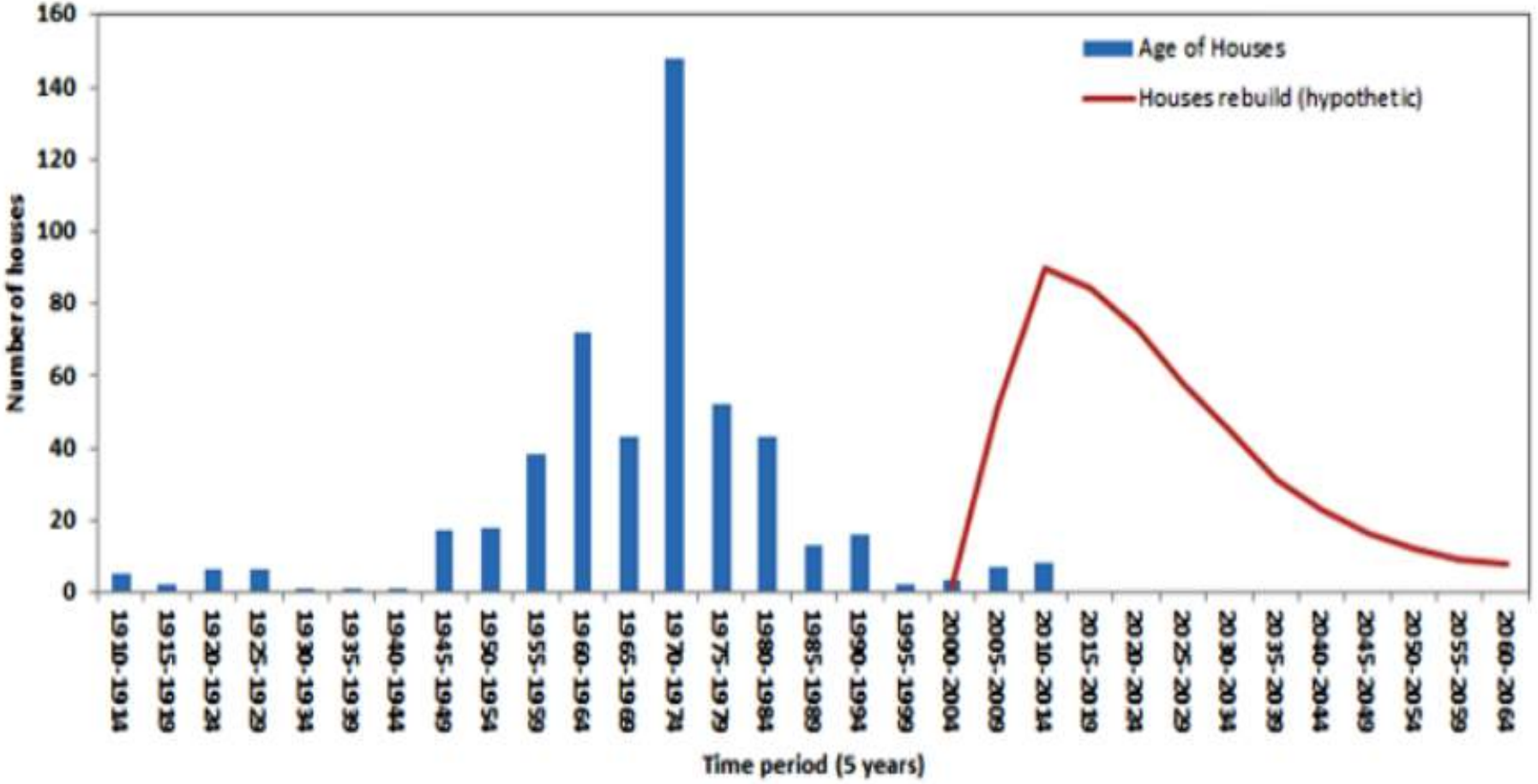
Hydrology



Change

EIA

Hydrology



Time when Houses were first built

Projected Rebuilding

Based on 2003-2009 Changes and
Rebuiliding Rates based on House Age
Projected 50-80 % Urban Renewall over the next 30 years

Summary: Managing Water at the Municipal Level

WATER CONSERVATION

1. WATER METERS
2. VOLUME BASED PRICING
3. LOW FLUSH TOILETS
4. LEBELING WATER USE ON APPLIANCES
5. OUTDOOR WATER USE REDUCTION
6. RAINWATER HARVESTING
7. 30 CM OF TOPSOIL BEFORE PLANTING GRASS
8. XERISCAPING (REDUCING SIZE OF LAWN)

SOURCE WATER PROTECTION

SURFACE WATER

1. SOURCE CONTROL
2. LAND USE CONTROL (ZONING)
3. BUFFER ZONES
4. WETLANDS
5. BENEFICIAL MANAGEMENT PRACTICES

GROUNDWATER

1. CONFINED vs. UNCONFINED
2. VULNERABILITY ASSESSMENT
3. LAND USE CONTROL OVER CAPTURE ZONE
5. SOURCE CONTROL

Summary: Managing Water at the Corporate Level

ACCOUNTING FOR WATER USE

1. LOCAL WATER ACCOUNTING
2. BLUE & GREEN WATER ACCOUNTING
3. WATER ACCOUNTING IN SUPPLY CHAIN
4. LEBELING WATER USE ON APPLIANCES
5. INITIATING CONSERVATION METHODS
6. CONSIDERING GLOBAL WATER
7. USING LOCAL AND SUPPLY CHAIN WATER SUPPLIES IN A SUSTAINABLE MANNER

ACCOUNTING FOR WASTEWATER

1. DETERMINING THE WASTEWATER LOAD
2. IDENTIFYING APPROPRIATE TREATMENT
3. SOURCE CONTROL (LIMIT WASTE INPUT)
4. GREY WATER REUSE
5. ACCOUNTING FOR WASTE IN SUPPLY AND DISTRIBUTION CHAIN
6. CONTINGENCY MEASURES FOR SPILLS AND ACCIDENTS RELATED TO WASTEWATER

DEVELOP A CLIMATE CHANGE ADAPTATION STRATEGY TO REDUCE RISKS

Summary: Managing Urban Stormwater

Detention, Infiltation, Temporary Storage

Property Scale

1. RAIN INTERCEPTION BY TREES
2. GREEN ROOFS
3. ROOFWATER COLLECTION
4. SOIL IMPROVEMENT (Infiltration)
5. RAIN-GARDENS
6. REDUCING IMPERVIOUS SURFACES
7. PERVIOUS PAVEMENT

Neigbourhood Scale

1. NO CURBS & GUTTERS
2. SMALLER ROADS WITH SWALES
3. DETENTION PONDS
4. WETLANDS
5. PERVIOUS PARKING LOTS
6. SWALES IN PARKING LOTS
7. INFILTRATION SYSTEMS

Watershed Scale

1. LARGE BUFFER-ZONES
2. NATURAL CHANNELS
3. FLOOD ZONING
4. DESIGNATE AREAS FOR FLOOD STORAGE
5. WETLANDS FOR STORAGE A AND TREATMENT
6. REDUCE IMPERVIOUSNESS

http://mlws.landfood.ubc.ca/videos/

Innovations in Stormwater Management Video Series

The Master of Land and Water Systems program team has produced a series of videos that introduce the emergence of innovative designs a
to urban stormwater management. The series focuses on stormwater management at three different scales:

- **Introduction** to Innovative Stormwater Management (4:50)
- Innovative Stormwater Management at the **Property Scale** (15:35)
- Innovative Stormwater Management at the **Neighbourhood Scale** (14:19)
- Innovative Stormwater Management at the **Watershed Scale** (10:12)
- **Map of Locations**